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DEPARTMENT OF MINES

HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY

W. H. COLLINS, DIRECTOR

Summary Report, 1921, Part D

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OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1922

No. 1958

SUMMARY REPORT, 1921, PART D

AN EXPLORATION NORTH OF THUNDER BAY, ONTARIO

By T. L. Tanton

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INTRODUCTION

The latter part of the field season of 1921 was spent in making a reconnaissance survey of an unsubdivided area which lies west of Dorion township and north of the townships through which the Canadian Pacific and Canadian National railways run in their course along the north shore of Thunder bay in northern Ontario. The results obtained form an important contribution to the geography of a map-sheet which is in course of preparation; in large part they deal with an area which is very difficult of travel and which is shown blank on existing published maps. A description is given here of the new canoe routes into this little known area which were found and surveyed in 1921. The information will eventually be incorporated into a map of the district, but as given here may in the meantime prove sevriceable to prospectors and others interested in the territory to which the route leads.

DESCRIPTION OF ROUTE

The solid rocks of the district and along the route here described are all Precambrian. They are readily subdivisible into an early Precambrian group of complex structure and a late Precambrian succession of little disturbed sediments and associated igneous rocks. The Basement Complex consists of a Schist Complex and granitic Batholithic Intrusives. The Schist Complex consists of two lithologically distinct divisions one of which is composed almost entirely of banded biotite schist and the other of dense, fine-grained chlorite, hornblende and sericite schists, and banded iron formation. Of the younger Precambrian rocks only the Keweenawan sediments and diabase intrusives are well developed. Animikie sediments were not found underlying the Keweenawan to the north of Loon.

From Dorion station an excellent road runs through the agricultural settlement in Dorion township, rising gradually for 6 miles to the old post-Glacial lake floor where it touches Mr. Gambles' farm on lot 14, concession V. From there the route follows Bishop's trail over boulder clay for 1½ miles to a branch road that leads northerly and slopes gradually down for one-half mile to the south bay of Wolf lake.[1]

Wolf lake is a beautiful sheet of water 4 miles long and averaging a quarter of a mile in width; its southern half is bordered by glaciated, bare hummocks and ridges of granite and gneiss which rise from 30 to 50 feet above the water. The outlet is at the eastern extremity where a shallow rapid runs over gravel. Keweenawan sediments in horizontal attitude overlie the granite rocks within a mile of the lake shore on either side.

[1] Shown on Map 1811, Geol. Surv., Can., Sum. Rept., 1919, pt. E.

On the east shore, nearly opposite the middle of the lake, a great sill of diabase 300 feet thick appears and under it, on the great cliff face, a few feet of Keweenawan limestone can be seen above the lake level. Mesa-shaped remnants of diabase extend away to the east and northeast, and ridges of the same rock extend southwesterly from the opposite shore. The zone trending north 20 degrees east and one-half mile wide, in which the diabase occurs so abundantly, is regarded as a favourable prospecting ground for lead, zinc, copper, and silver minerals, which are commonly associated in veins occupying faults and fissures in rocks of this type.

The northern end of Wolf lake is surrounded by low land, drift-covered and presumably underlain by Keweenawan sediments. From the head of Wolf lake a portage half a mile long leads over almost level boulder clay to a bay on Wigwam lake. Wolf river, between the two lakes, is a broad shallow stream flowing rapidly over boulders.

Wigwam lake occupies a linear basin which, but for the occurrence of a boulder barrier at its outlet, would be a continuation of Wolf lake. The southern half is bordered by low drift-covered shores, but Keweenawan red tuff outcrops as cliffs along the northern half. These cliffs gradually become higher and closer together and at the northern extremity they are 50 feet high. Two large blocks which have fallen from the cliff on the east side of the lake form a prominent land mark on the shore. A small stream, Balsam Brush creek, enters at this point after traversing a short gorge in a series of falls and rapids. A portage 1,000 feet long was cut to a navigable expansion of this stream, but its exploration was discontinued on account of shallow water and obstructing logs. A land traverse indicated that a sand and boulder clay plain extends at least a mile north and northeast from the head of Wigwam lake.

Wolf river enters Wigwam lake midway, on the west shore. The river makes a sharp bend just above its mouth and a tangle of driftwood piled up among the trees nearby indicates that at times of high water it flows directly across the forested, bouldery barrier along the lake shore. A portage of 1,500 feet leads from a point 400 feet northwest of the river mouth to the outlet of Red Rock lake. The trail ascends a gentle sand and boulder slope for 500 feet, and after mounting a low cliff of Keweenawan sandstone follows down its gently dipping surface to Red Rock lake.

The eastern shore of Red Rock lake is composed of low-lying Keweenawan sandstone and drift. On the western shore granite occurs along the southern half. Near the narrows to the north a small area of red tuff rises abruptly 100 feet above the lake. The northern end of the lake consists of an intricate system of shallow channels enclosing shrub-grown marshy areas. The river above the lake meanders through a silt and clay plain which stands 10 feet above river-level. This is the first area of land fit for agriculture encountered since leaving the Dorion farming area. Six hundred feet upstream from the lake there is a fall 7 feet high over a cliff of nearly flat-lying red dolomitic tuff and sandstone; a portage 700 feet long on the right avoids this obstruction.

One mile above the lake there is a shallow rapid and a sharp turn in the main stream; at the bend a large tributary enters from the northwest. The course up the main stream is pursued southwesterly by following a portage on the right, 1½ miles in length, which starts below the rapids and the tributary's junction. Half-way across this portage, one passes from the soil plain to an area of thinly covered Keweenawan sediments. A remarkable view is obtained, near the upper end of the portage, of the river descending in a series of cascades and rapids through a main gorge which has been incised to a depth of 20 feet through horizontally bedded, red, dolomitic tuff. Within the gorge certain irregular areas of rock stand up prominently and divide the river, at periods of low water, into several channels.

No falls or rapids occur for 1½ miles above this long portage; this is the longest stretch of smooth water on Wolf river. Two log jams are passed by portages on the right. In proceeding southerly upstream the area near the river is a plain standing 8 feet above the river and heavily covered with silt. Low hills rise a short distance back from the river and become higher and closer to it as one travels

upstream until at the 11-chain portage an area of considerable relief is encountered. The river here falls 20 feet, and the portage is on the right over white sandstone. This sandstone is nearly flat-lying and is traversed by a number of open fissures and well-developed rectangular joints. At an abrupt turn in the river about 500 feet above the 11-chain portage the valley crosses what is probably a fault. The outcrops in this vicinity, though abundant, are not disposed in such a way as to render possible a positive interpretation of the solid rock geology. The rock in the bed of the stream at the foot of the long rapids 500 feet west of the abrupt bend is pink granite and pegmatite of the Basement Complex. The banks of the river rise very steeply on either side to a height of 200 feet, and expose the best section of Nipigon sediments which occurs along this route. Lying on the slightly weathered granite there is a basal conglomerate 20 feet thick composed of granite fragments in a sandstone matrix. Above this is a conformable series of flat-lying sediments made up of 100 feet mostly of sandstone, succeeded by nearly 100 feet of red tuff. The long rapids are passed by a portage along the top of the cliff on the left side of the river. At 1½ miles above the lower end of this portage, the river-level is the same as that of the stratum of red rock which forms the top of the tableland, and it is obvious that in this distance the river makes a descent of approximately 200 feet. The course of the river, from the upper end of the long rapids to the junction of Greenwood creek, is southwesterly for 2 miles, and westerly for 2 miles, and in this part of the route there are five portages as follows: 3,000 feet, on the right; 400 feet, on the left; 900 feet, on the right; 400 feet, on the left; and 40 feet, on the left.

In this locality the country is of low relief and outcrops of granite and Nipigon sediments are equally numerous. No features of economic interest were observed and it is certain that the sediments occur as thin remnants of an horizontal covering over the gently undulating surface of the Basement Complex.

Twelve miles in a straight line west from the north end of Wolf lake, Greenwood creek enters Wolf river as a sluggish stream 20 feet wide and 1 foot deep. It is navigable for 1,300 feet above the confluence and then disappears among boulders. Granite hills rise 60 feet on either side of the valley; the declivity is abrupt on the right and a portage 1,250 feet long starts from the left bank. Upon reaching the highland, a scale of sandstone is found lying on the granite and by following westerly along the relatively smooth surface thus afforded, Wolf river is reached. The new route, which leads to Greenwood lake, branches southward from a point on this portage 750 feet from its lower end, and after traversing 1,000 feet over boulder-strewn, granite hills, reaches navigable water above a large beaver dam.

Greenwood creek is a very small stream during dry seasons and the total length of the numerous portages which occur between its mouth and Greenwood lake is about 2 miles. It occupies a remarkably straight valley and the granite hills and ridges, which are less than 100 feet high near its mouth, gradually increase in going 4 miles southerly, to a height of 700 feet above the stream.

A large diabase dyke occurs on the portage which is 1½ miles above the mouth of the river. With this exception all the rock observed along the creek is granite and pegmatite. The only noteworthy tributaries flowing into Greenwood creek enter from the south and east at three-quarters of a mile, 1 mile, and 2 miles respectively, below Greenwood lake. These are unnavigable, though they occupy deep valleys. An abrupt change in the direction of Greenwood Creek valley from south to south-west, occurs one mile below the lake, but along the projected line of the river's trend to the south there are a number of prominent drainage features which indicate the existence of a rock valley over 20 miles in length trending almost parallel to the west boundaries of Dorion and McTavish townships and approximately 3½ miles west of this line.

Greenwood lake is of the linear type, being nearly 7 miles long, and averaging a quarter of a mile in width. Its outlet is 4½ miles west and one mile north of the northwest corner of Dorion township; its southern extremity is 3 miles west and 1¼

miles north of the southwest corner of Dorion. The main axis of the northern half of the lake trends north 30 degrees west. An exploration was made in this direction 6 miles beyond the lake. Three small lakes which drain northeasterly into Wolf river were traversed and beyond these, over a divide, upper Wolf river was crossed where it comes from the southwest through a hilly, granite country and turns easterly in an area underlain by Keweenawan sediments. At the bend a stream joins from the northwest, and, a short distance above, two streams join from the southeast and south; none of the streams are navigable. From the sudden change in the relief and geology which occurs near the bend it might be inferred that the area to the north of the high granite hills had been downfaulted; and from the alignment of the rock valleys in a direction north 30 degrees west from the northerly end of Greenwood lake it might be inferred that this marks the position of another fault of less magnitude. Further field work will be necessary in order to verify these inferences.

The drift mantle is very thin over the rugged granite and gneiss area which surrounds Greenwood lake. At the southern end, however, there are very large eskers in the rock valleys and these form part of the divide between the tiny tributaries to the lake and the southward-flowing streams at the headwaters of Mackenzie river. The long, straight valleys in this rocky area appear to be due to faults, but the character of the rocks on either side is such as to make a determination of this matter difficult. It is known, however, that the belt of schist complex which trends nearly east from the southern end of the lake does not occur on the western shore along the continuation of this strike; also, a fault has been observed trending parallel to the axis of Greenwood lake, a short distance west of it.

Land traverses were made westerly from several points along Greenwood lake, and the divide between this part of Wolf River system and the southwesterly flowing waters of Current river was located; but no portages were cut. A land traverse southwesterly from the south end of the lake crossed upper Mackenzie waters which were unnavigable where seen.

The portage from the south end of Greenwood lake to White Granite lake is 1½ miles long and runs south 80 degrees east. The rock on the highland crossed by the trail is granite-gneiss cut by numerous quartz veins; greenstone schists occur both to the north and south at a short distance.

White Granite lake, and Shallow lake—which adjoins it on the east—are boggy ponds each about three-quarters of a mile long. The portage between them starts at the east end of White Granite lake and leads southeasterly a quarter of a mile. It crosses a high, narrow ridge of coarse-grained, white, binary granite.

The creek which flows southeasterly from Shallow lake to Mackenzie lake, 2 miles distant, is unnavigable except where ponds have been formed above beaver dams. A belt of banded mica schists and green schists 1½ miles wide is crossed by this creek. Granite occurs on the portage a few hundred feet before Mackenzie lake is reached.

Mackenzie lake occupies the northwest corner of McTavish township, and from here the route south to Loon station on the Canadian Pacific railway is through McTavish township, continuing almost parallel to its western boundary and one mile east of it. From the eastern shore of the southern extension of Mackenzie lake the portage leads easterly for a quarter of a mile, to a trail between Clegg and Twin lakes at a point one mile north of the latter. Twin lake, which is part of the Pearl River system, is a narrow body 1½ miles long. A portage 3,000 feet long leads south-southwest to the northeastern shore of Wideman lake. The next portage is only a quarter of a mile distant, across the east bay, at the outlet of Wideman lake; it leads south 1,300 feet to Anderson lake. This narrow lake permits canoeing for a little over half a mile; from its outlet to Kline point on Loon lake there is a portage 2 miles in length. At one mile south of Anderson lake a trail branches to the southeast and leads to the mouth of the creek which enters the northeastern end of Loon lake. Loon station is on the southern shore of Loon lake, three-quarters of a mile from

Kline point. The route from Mackenzie lake to Loon lake is through a rugged granite-gneiss area except for the last third of a mile, which is underlain by Keweenawan sandstone. The geology of a small area immediately surrounding Loon lake is very complex; Keweenawan and Animikie sediments overlie a Basement Complex of Keewatin schists, pre-Huronian sediments, and Batholithic Intrusives. These have been intruded by diabase dykes, and sills and faults traverse the whole assemblage.

ECONOMIC GEOLOGY

Very little of the area mapped on this exploratory trip has been prospected, and the following notes are designed to indicate the mineral possibilities with particular reference to the various geological divisions.

Schist Complex. The area underlain by the Schist Complex in southwestern Dorion is small and presents no features which would indicate that it was a promising field in which to prospect for the minerals commonly sought in Keewatin areas, viz., gold and iron. Numerous barren quartz veins were noted in these rocks; and, when small stocks of granite of younger age than the regional granitic gneiss are found to intrude the schists, veins of similar general appearance may be expected to carry gold.

Batholithic Intrusives. The granitic rocks which form the bulk of the highlands that extend 18 miles north of Loon lake are to be regarded as favourable prospecting grounds for veins carrying silver, lead, and zinc, because faults, presumably of post-Keweenawan age, related in trend and position to diabase dykes, occur in this area. Deposits of molybdenite may occur in the pegmatite dykes. Molybdenite occurs as a primary mineral in pegmatite composed essentially of quartz and red feldspar, on the trail along the east side of Anderson lake, concession VIII, lot 5, McTavish township. The pegmatite is for the most part barren, but certain small, irregularly distributed masses of the rock contain sufficient molybdenite to make a one-per-cent ore. The molybdenite is coarsely crystalline and it would be possible to obtain rich ore by hand-cobbing. The distribution of the molybdenite precludes, in the writer's opinion, the possibility of profitable extraction under present market conditions.

The granitic batholiths of northern Ontario have usually been regarded as unpromising areas in which to search for gold, but the geological work so far done is not sufficient to determine the age relations of the various granitic rocks in the Basement Complex, and there is a possibility that younger granite intrusives may occur, around the margins of which in the older gneisses gold-bearing veins may be found.

Animikie Series. Rocks of the Animikie series do not occur on the highlands north of Loon lake, and they are absent under the thin scale of Keweenawan sediments which overlies the granitic rocks on the north. The Animikie rocks are also absent under the marginal Keweenawan sediments, which overlie the granite at the southerly margin of the granitic highlands half a mile north of Loon lake. To the south of Loon lake the Keweenawan sediments are underlain by the Animikie rocks. Both series dip at low angles toward the south-southeast and have been intruded by diabase dykes and sills and the whole assemblage faulted.

The iron ore occurrences near Loon lake are at present the chief objects of interest to those concerned with the development of mineral deposits in the district. The result of this exploration permits of a small contribution to the general study of the Animikie iron deposits in that it is now possible to state that the boundary of the Animikie rocks at Loon lake coincides approximately with the margin of the original basin of Animikie deposition, the deeper part of which lay toward the south. No rocks which could be recognized as having contributed to the formation of the Animikie sediments either in the form of detritus or igneous emanation were encountered in the highland area.

Keweenawan Sediments. Keweenawan sediments up to 200 feet in thickness occur in nearly horizontal attitude over the greater part of the country lying northeast and south of the granitic highlands which extend 18 miles north of Loon lake and which narrow abruptly about the middle of Dorion township and extend easterly to Granite point. The series consists of conglomerate, sandstone, red volcanic ash, and limestone. At certain localities the different varieties of the fine-grained sediments are suitable for building stone.

The basal conglomerate seen in the valley of Wolf river, in Stirling township, and in the outcrops north of the east end of Loon lake, and in the rock cut one mile west of Loon is remarkable in that the matrix between the pebbles is composed largely of limestone. This is unusual in this member in the area examined to the south. Nothing of commercial value has been found in this peculiar conglomerate, but in Stirling township certain blocks of the limestone-cemented conglomerate were polished by L. H. Cole of the Mines Branch, Department of Mines, who reported on certain building stones in this locality, and were found to carry small specks of argentite. This occurrence of the silver mineral in a conglomerate matrix not associated with a vein is quite unusual.

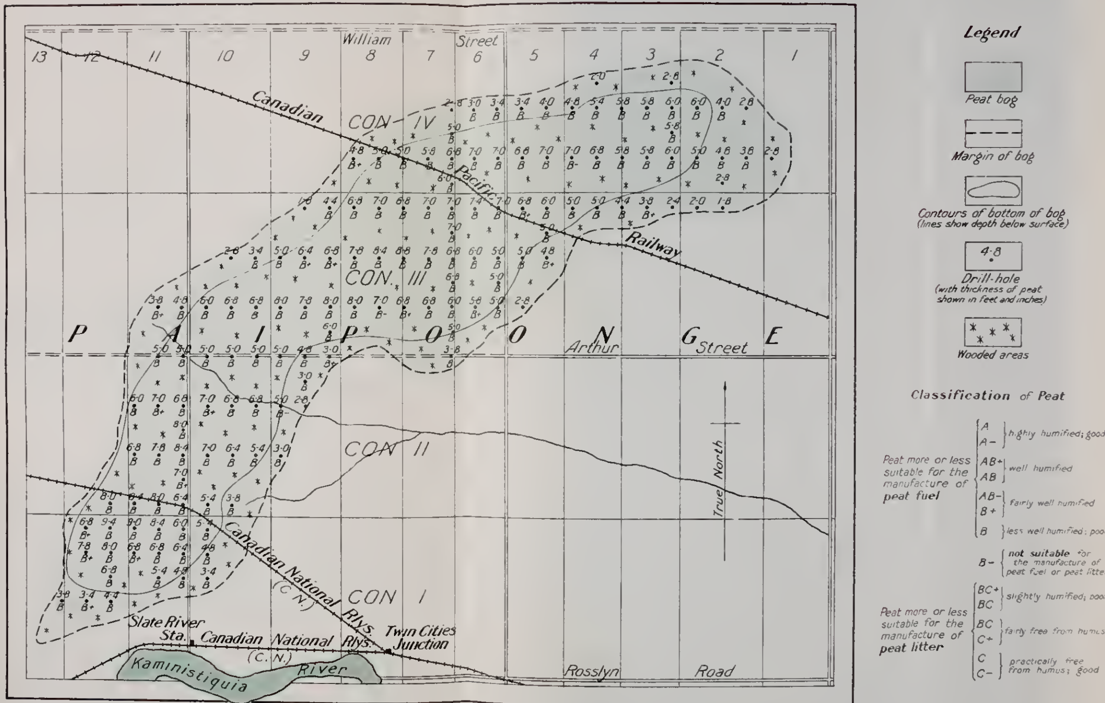
Faults of late Keweenawan age traverse the Keweenawan sediments, and the mineralized vein material which cements the fault fissures is, apparently, the chief economic feature.

Keweenawan Irruptives. Diabase dykes intrude all the previously-mentioned solid rocks, and there are many sills of diabase in the Animikie and Keweenawan sediments. The mapping of these irruptives in the rugged, forested areas is difficult, and a great deal of traversing has yet to be done before the extent of the various bodies can be delimited.

The extensions of certain of the great diabase dykes shown on Map 1811, Geological Survey, were located at certain points. The exposed diabase irruptives of this region are supposed to be parts of a great igneous body which, in the late stage of its cooling, gave off those metallic constituents that now form part of the vein-material in the faults and fissures of late Keweenawan age. None of the known well-mineralized veins occur within the diabase, although they are, in most cases, near and oriented in relation to diabase intrusives. Prospectors are advised to search for mineralized veins along faults which traverse or border the diabase masses.

Late Keweenawan Veins. For a general note on the mineral character and occurrence of the late Keweenawan veins in this general area reference may be made to the Summary Report of the Geological Survey for 1919. In the course of the exploration, though no prospecting was attempted, several late-Keweenawan veins were observed. Most of these are exposed on the highlands along the route between Loon and Mackenzie lakes; they trend northeasterly and are small and barren except for occasional crystals of galena. It is probable that larger veins occur in the linear topographic depressions which parallel the course of the veins, for example, the valley followed by the stream draining Mackenzie lake.

An interesting vein was discovered at a point 1,200 feet west of the base of a cove on the west side of Greenwood lake and 1½ miles north of its south end. A brecciated fault zone was there found to trend north 10 degrees west across the foliation of the gneiss. The shattered rocks are filled with a cement of quartz and a small amount of galena, and through this, close to the eastern wall, a later fissure had been filled with a vein of coarsely crystalline marcasite averaging 1½ feet in width through the exposed distance of 50 feet. Chemical tests of the marcasite reveal no precious metals or impurities. It is the only vein of this character known in this region, except where the landward extension of Silver Islet vein crosses the "anorthite" dyke.



Geological Survey, Canada

Publication Nº 1953.

Arthur Peat Bog, Paipoonge Township, Thunder Bay District, Ontario.

To accompany Report by A. Anrep, in Summary Report, Part D, 1921.

Scale, 2400 feet to 1 inch

1000 0 1000 2000 3000 4000 5000

Peat surveys by **A Anrep, 1921.**

INVESTIGATION OF PEAT BOGS IN ONTARIO[1]

By A. Anrep

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INTRODUCTION

Four peat bogs were surveyed during the summer season of 1921, in order to determine the area, depth, and qualities of peat contained in each. This investigation started late in June and was carried on during July, August, September, and part of October. E. M. Casey acted as a field assistant. A total area of 11,089 acres of peat bogs was investigated in Ontario during 1921.

Three of the four bogs surveyed are situated near the cities of Fort William and Port Arthur. These are called here the Arthur, William, and Twin Cities bogs. The fourth bog surveyed is situated near Verona, in Addington and Frontenac counties.

ARTHUR PEAT BOG

This bog is about 9 miles west of Fort William in the township of Paipoonge, Thunder Bay district. It extends in a northeast and southwest direction (*See* Map 1953). The total area is about 1,474 acres.

Of this area 542 acres have a depth of less than 5 feet with an average depth of 3 feet, and 932 acres have a depth of more than 5 feet with an average depth of 7 feet. The volume of peat contained is 2,623,000 cubic yards in an area with a depth of less than 5 feet, and 10,523,000 cubic yards in an area with a depth of more than 5 feet. The bog is rather shallow, but it is free from knolls and the surface is quite level and would make an admirable drying field. Most of the surface is heavily wooded with alders, dwarf spruce, dwarf birch, and poplar. The southwestern side of the bog could not be used as a drying field because it is margined on that side by an abrupt bank. The bog can easily be drained as it is 45 feet above the Kaministikwia river, and the southern end of the bog is only 1,000 feet from the river.

The peat in this bog is fairly well humified and could be manufactured for fuel. The peat is heavily intermixed with roots and stumps, but in most cases these are sufficiently decomposed for a drill to penetrate. Samples show that the peat is composed mainly of carex plants slightly intermixed with sphagnum and eriophorum, the former being the more prevalent.

The bottom is formed of reddish sand intermixed with clay.

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[1] All figures in this report are approximate. A ton is considered as 2,000 pounds. A cubic yard of drained bog is assumed to be equal to 200 pounds of dry peat.

In the tables of analyses, figures in column R refer to fuel as received, and in column D to fuel dried at 105°C. The analyses were made on the fuel as received and the other results were calculated therefrom.

The 542 acres less than 5 feet may be excluded from consideration as a commercial source of peat. Allowing 2 feet for the decrease in depth through drainage, the remaining 932 acres would have an average depth of 5 feet and a total of 7,518,000 cubic yards. The total dry tonnage is 752,000 tons or 1,003,000 tons of peat fuel having 25 per cent of moisture.

Analysis of Peat from the Arthur Peat Bog

Sample	I		II		III	
	R	D	R	D	R	D
Moisture.......%	7·3	....	9·1	....	9·0	....
Ash.......%	13·9	15·0	12·3	13·4	12·5	13·7
Volatile matter.......%	52·8	57·0	52·4	57·7	53·3	58·6
Fixed carbon (by difference).......%	26·0	28·0	26·2	28·8	25·2	27·7
Sulphur.......%	0·4	0·4	0·5	0·6	0·5	0·6
Nitrogen.......%	1·8	1·9	1·6	1·7	1·5	1·6
Calorific value in calories per gram, gross.......	4,160	4,490	3,840	4,230	3,980	4,370
" value in B.Th.U. per lb., gross.......	7,480	8,070	6,920	7,620	7,160	7,860
Fuel ratio, fixed carbon, volatile matter.......	0·49	0·49	0·50	0·50	0·47	0·47

WILLIAM PEAT BOG

This bog is situated near Fort William and Port Arthur, in McIntyre and Neebing townships. It extends in a northeast and southwest direction (*See* Map 1952).

Its total area is 1,789 acres. Of this area 926 acres have a depth of less than 5 feet with an average depth of 3 feet, and 863 acres have a depth of more than 5 feet with an average depth of 7 feet. The volume of the peat contained is 4,482,000 cubic yards in an area less than 5 feet deep and 9,743,000 cubic yards in an area more than 5 feet.

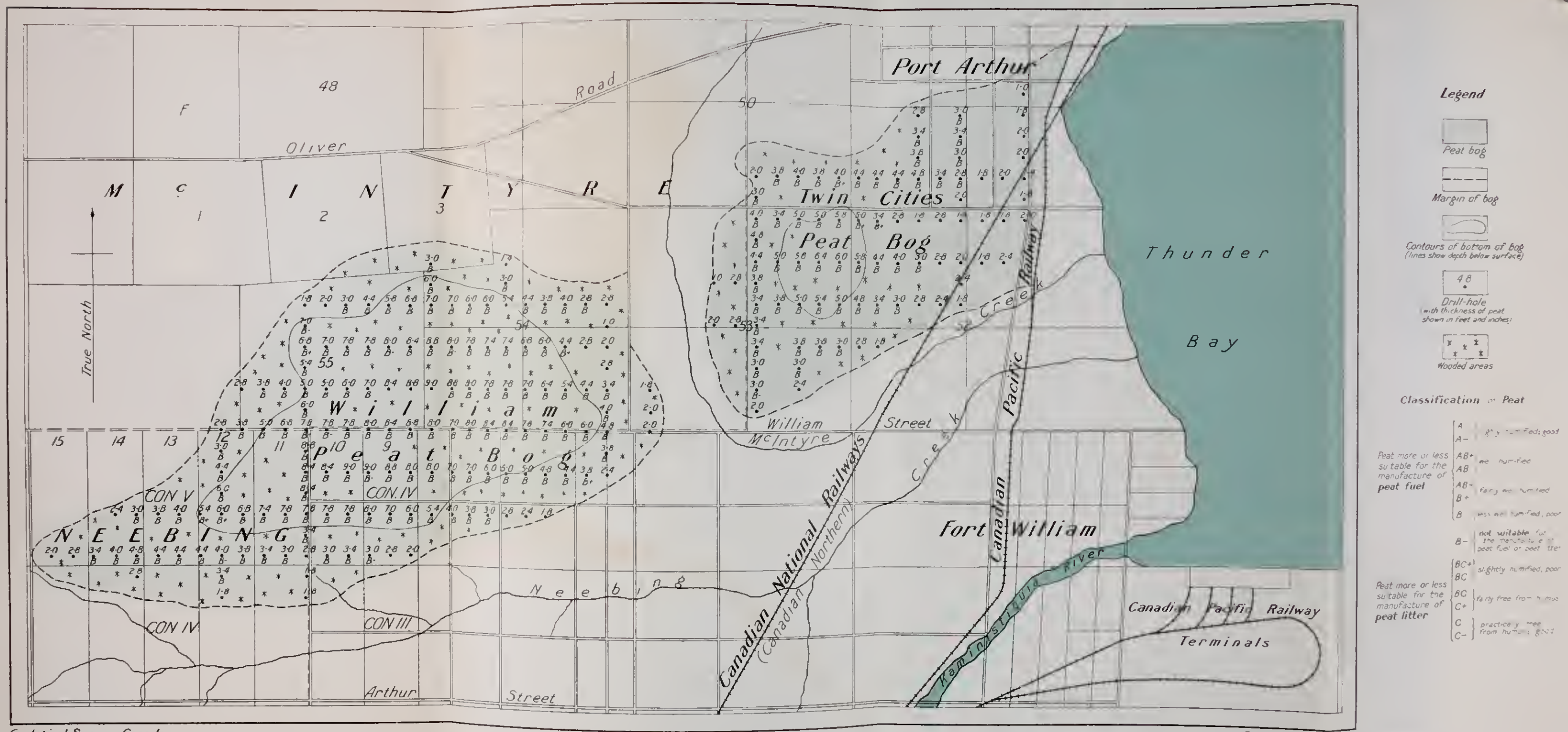
The peat is fairly well humified and could be utilized for the manufacture of machine peat fuel. It is slightly inferior to the peat in the Arthur bog. It is rather shallow, but the surface is free from knolls and is comparatively level and, therefore, suitable as a drying field. The entire surface is heavily wooded with spruce, alders, dwarf birch, and poplar. This bog could be easily drained, as the eastern end is situated 1,000 feet from McIntyre creek and the southern end is about the same distance from Neebing creek, both of which flow with a free current. Stumps and roots were encountered, which do not seem to be as well decomposed as those in the Arthur bog, but they should not amount to a serious hindrance. The peat is mainly composed of carex plants, heavily intermixed near the surface with sphagnum; occasionally, eriophorum is found. Remains of various aquatic plants were visible in the deeper section of the bog.

The bottom is formed of reddish sand intermixed with clay.

The samples were found greatly deficient in cohesive properties. This is due to the frost penetrating almost the entire thickness of peat before snow covered the surface. Such occurrences seem to be characteristic of this part of the country.

Both the Arthur and William bogs are very conveniently situated as regards market. The Arthur bog is traversed both by the Canadian Northern and Canadian Pacific railways and the William bog is situated in the immediate vicinity of the Twin Cities.

Excluding from consideration the 926 acres of bog which is less than 5 feet deep and allowing 2 feet for drainage, there are approximately 863 acres of utilizable peat with an average depth of 5 feet. The total volume is 6,962,000 cubic yards. The total dry tonnage is 696,000 tons or 928,000 tons of peat fuel having 25 per cent of moisture.



Geological Survey, Canada

Publication No 1952

Twin Cities, and William Peat Bogs, Thunder Bay District, Ontario.

To accompany Report by A. Anrep, in Summary Report, Part D, 1921

Scale, 2400 feet to 1 inch

1000 0 1000 2000 3000 4000 5000

Peat surveys by A. Anrep. 1921.

Geological Survey, Canada

Verona Peat Bog, *Camden East and Portland Townships, Lennox and Addington, and Frontenac Counties*

Scale, 2400 feet to 1 inch

1000 0 1000 2000 3000 4000 5000

To accompany Report by A Anrep,
in Summary Report, Part D, 1921

Publication Nº 1951

ac Counties, Ontario.

Peat surveys by *A Anrep, 1921.*

Analysis of Peat from the William Peat Bog

Sample		I R	I D
Moisture	%	6·2	....
Ash	%	10·6	11·3
Volatile matter	%	59·3	63·2
Fixed carbon (by difference)	%	23·9	25·5
Sulphur	%	0·3	0·4
Nitrogen	%	1·7	1·8
Calorific value in calories per gram, gross		4,500	4,800
Calorific value in B. Th. U. per lb., gross		8,100	8,630
Fuel ratio, fixed carbon, volatile matter		0·41	0·41

TWIN CITIES PEAT BOG

This bog lies within the city limits of Fort William and Port Arthur. It extends in a northeast and southwest direction (*See* Map 1952). The total area is 993 acres, of which 895 acres have a depth of less than 5 feet with an average depth of 3 feet, and 98 acres have a depth of more than 5 feet with an average depth of 5 feet. There are 4,332,000 cubic yards in the area with a depth of less than 5 feet and 794,000 cubic yards in the area with a depth of more than 5 feet.

The peat is fairly well humified and is suitable for fuel. The bog is very shallow but it is already thoroughly drained, as this section has been laid out for the expansion of the Twin Cities and is, therefore, never likely to be worked for peat.

It is almost free from wooded growth and the surface is level. This bog is mostly composed of sphagnum slightly intermixed with carex and eriophorum plants.

The bottom of the bog is formed of reddish sand intermixed with clay.

The 895 acres with a depth of less than 5 feet may be left out of consideration as a source of commercial peat. As the bog is already thoroughly drained no shrinkage allowance for drainage need be made for the remaining 98 acres with an average depth of 5 feet, which have a total volume of 791,000 cubic yards of peat. The total tonnage of dry substance is 79,000 tons, or 105,000 tons of peat fuel having 25 per cent moisture.

Analysis of Peat from the Twin Cities Peat Bog

Sample		I R	I D
Moisture	%	6·7	....
Ash	%	8·0	8·6
Volatile matter	%	58·2	62·4
Fixed carbon (by difference)	%	27·1	29·0
Sulphur	%	0·5	0·5
Nitrogen	%	1·4	1·5
Calorific value in calories per gram, gross		4,520	4,850
Calorific value in B. Th. U. per lb., gross		8,140	8,730
Fuel ratio, fixed carbon, volatile matter		0·46	0·46

VERONA PEAT BOG

The east end of this bog lies south of Verona, the central part is south of Bellrock, and the western part, about one mile south of Enterprise, in Camden East and Portland townships, Addington and Frontenac counties (*See* Map 1951). Its total area is 6,833 acres. Of this area: (a) 1,429 acres have a depth of less than 5 feet with an average depth of 4 feet; (b) 2,121 acres have a depth of from 5 to 10 feet with an average depth of 7 feet; (c) 1,881 acres have a depth of from 10 to 15 feet

with an average depth of 12 feet; (d) 1,302 acres have a depth of from 15 to 20 feet with an average depth of 16 feet; and (e) 100 acres have a depth of more than 20 feet with an average depth of 20 feet.

The volume of peat contained is approximately:

9,222,000	cubic yards in..	(*a*)
23,963,000	" "	(*b*)
36,418,000	" "	(*c*)
33,618,000	" "	(*d*)
3,230,000	" "	(*e*)

The bog is deepest between Verona and Bellrock and if the surface there were cleared and the bog properly drained it would be very suitable for fuel. It has the special advantage of long working lines and wide spreading fields. The bog in Camden East township, though shallower, is of satisfactory depth and has good working lines. Both of these sections would be suitable for the manufacturing of peat by any of the present known methods, which require long and wide spreading and drying fields.

The bog south of Verona is divided by Hardwood creek which flows south into Cameron creek. The section between Cameron cut and Hardwood creek drains into Napanee lake which in turn drains down Napanee river. The bog west of Depot river drains into Cameron creek which flows towards Cameron cut. The land rises considerably on either side of the bog so that it lies more or less in a continuous valley.

The surface has been flooded during the greater part of the spring, but since the dam at Cameron cut was removed it has a better chance to dry.

The peat throughout the whole bog is very well humified, has good cohesive properties, and possesses a considerable depth. The peat is composed mainly of carex remains of grasses, dead trees, and shrubs. No sphagnum was encountered and only once a few hypnum plants were noticed. The bottom layers of the bog are composed of aquatic plants below which is a layer of about 2 or 3 feet in depth of greenish gelatinous substance which seemed to be composed of vegetable and diatomaceous siliceous shells, freshwater mollusks, and littoral remains. The greater part of the peat is thickly intermixed with roots, logs, and stumps. The bog is very heavily wooded with ash, soft maple, birch, willows, poplars, alders, and numerous other varieties of deciduous bushes.

The bottom of the bog is a thin layer of blue clay under which stone or sand is encountered.

This bog is very well situated as regards market and shipping facilities, being surrounded by farming districts and small villages and touching at the east end the Canadian Pacific railway and at the west end the Canadian Northern.

Leaving out of consideration the 1,429 acres with a depth of less than 5 feet and allowing 3 feet for the decrease in depth through drainage, there is left:

		Feet
2,121	acres with an average depth of approximately..	5
1,881	" " " " " " "	10
1,302	" " " " " " "	14
100	" " " " " " "	18

There is a total volume of 79,768,000 cubic yards of utilizable peat and the total dry tonnage would be 7,977,000 tons or 10,636,000 tons of peat fuel having 25 per cent of moisture.

The drainage of this bog could be effected by blasting and deepening Cameron cut. The clearing and drainage in general would be rather costly, but, on a large scale, the peat could be manufactured on a commercial basis.

Analysis of Peat from the Verona Peat Bog

Sample	I		II		III		IV	
	R	D	R	D	R	D	R	D
Moisture.......................%	9·7	....	9·3	....	10·3	....	11·1	....
Ash............................%	15·6	17·3	13·4	14·8	12·0	13·3	19·7	22·2
Volatile matter.................%	54·8	60·7	55·9	61·6	55·2	61·6	48·4	54·4
Fixed carbon (by difference).....%	19·9	22·0	21·4	23·6	22·5	25·1	20·8	23·4
Sulphur........................%	2·1	2·3	1·6	1·7	1·4	1·6	1·0	1·1
Nitrogen.......................%	2·4	2·7	2·6	2·9	2·8	3·1	2·4	2·7
Calorific value in calories per gram, gross....................	4,130	4,570	4,130	4,550	4,200	4,680	3,780	4,250
Calorific value in B. Th. U. per lb., gross...........................	7,430	8,230	7,430	8,180	7,560	8,430	6,800	7,650
Fuel ratio, fixed carbon, volatile matter........................	0·36	0·36	0·38	0·38	0·43	0·43	0·42	0·42

SYNOPSIS OF INFORMATION CONCERNING THE PEAT SITUATION IN CANADA

By A. Anrep

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Peat is a combustible substance formed from vegetable matter by processes of accumulation through ages, and slow decay resulting in various degrees of humification.[1]

The degrees of humification and the quality of peat depend upon: (*a*) the temperature under which the peat was accumulated; (*b*) the kind of vegetation from which it is formed.

Following is a convenient and practical classification of peat based on the degree of humification:

Peat suitable for the manufacture of peat fuel	(A) (A—)	highly humified; good
	(AB+) (AB)	well humified
	(AB—) (B+)	fairly well humified
	(B)	less well humified; poor
	B—	not suitable for the manufacture of peat fuel or peat litter
	(BC+) (BC)	slightly humified; poor
Peat suitable for the manufacture of peat litter	(BC) (C+)	fairly free from humus
	(C) (C—)	almost free from humus; good

Peat in its natural state contains from 87 per cent to 92 per cent of moisture, according to the drainage of the bog. This content of moisture must be reduced to 25 per cent or 30 per cent before the peat can be used as efficient fuel; and to 20 per cent or 22 per cent of moisture to produce good peat litter.

Peat fuel bogs are formed from the following kinds of vegetable matter:

Mosses, especially sphagnum and hypnum.

Carex plants such as rushes, sedges, and grasses.

Scirpus and eriophorum plants such as club-rushes and cotton grasses.

Heath plants, aquatic plants, and trunks and roots, fallen trees and leaves, etc.

Peat litter bogs are former principally from the mosses, especially sphagnum.

Peat bogs are classified according to location and composition as:

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[1]Humification is here used to mean the change of vegetable matter into *humus* or vegetable mould, rendering the soil favourable to forest growth.

High Bogs: Formed principally of the remains of mosses, eriophorum plants, heath plants, and forest residue. Some of these bogs are shaped like enormous sponges and vary in depth from 3 feet to 30 feet or more towards the middle.

Low Bogs: Formed principally of remains of carex and aquatic plants, which require more nourishment than the plants forming the vegetation of high bogs. Low bogs are found chiefly in localities which are occasionally or periodically flooded. The depth varies from 1 foot to 9 feet or slightly more.

PEAT AS FUEL

The greatest difficulty in the economical manufacture of peat fuel is the removal of water. Up to the present the air-dried process has given the best results. This method has been greatly improved by processes that adapt it to weather and labour conditions. The season during which peat can be manufactured in Canada is very short, varying from 90 to 100 days, but under favourable conditions and with existing improved apparatus the manufacture of peat fuel should prove commercially successful if properly conducted.

The methods employed for the manufacture of air-dried peat fuel are:

Hand-cut peat; raw peat is cut out of the bog by hand and air-dried, without undergoing any mechanical treatment.

Wet or tramp peat; raw peat with water added to it is tramped by horses or men and, when of a proper consistency, is run into moulds in the open to be air-dried.

Machine peat; raw peat is dug mechanically or by hand and elevated into a macerator, where it is subjected to intense maceration. The macerated peat is mechanically transported and spread in the open where it is left to be air-dried.

As soon as the spread peat is sufficiently dry to be handled it is turned and after a few days is cubed, the cubes being piled in beehive-shaped heaps. This is done by hand and when manufactured on a large scale, the harvesting and the loading into railway cars are conducted mechanically.

One and four-fifths tons of machine peat are equal in calorific value to 1 ton of anthracite coal. Peat is, however, much more bulky, having 3·6 to 4 times the volume of anthracite. It is, therefore, more expensive to transport and for this reason the bog should be situated close to transportation and market. If the bog is not favourably located the manufactured peat may be burned in gas producers for the developing of electric energy; for the manufacture of by-products, chiefly ammonium sulphate; or it may be coked or converted into powder.

GENERAL USES OF PEAT

Peat is a good fuel for grates, cooking stoves, and Quebec heaters. It is very clean to handle and can be easily ignited; it burns with a long yellow flame and leaves as a rule a small deposit of yellow or red powdery ash free from clinkers.

Peat is well adapted for use in furnaces during the early spring and late autumn when a short, quick fire is desired; during the winter months it should be mixed with coal when the fire burns low. Our winters are too severe for peat to be used by itself in ordinary furnaces.

Peat has also been satisfactorily used under boilers, but it requires a great deal of stoking and feeding.

Peat litter is manufactured entirely from sphagnum mosses, which are almost free from humus. The raw peat is dug out with spades in brick form during the autumn months, spread out on the surface of the bog, and left to freeze until the following spring. After it has been air-dried it is brought to the plant and passed through a tearing machine. During this process a certain amount of "mull" is formed. The product from the disintegrator passes through a sieve and the two products are separated, and afterwards pressed separately into bales.

Peat litter having great absorption qualities and being a natural cleanser, is extensively used in northern Europe as bedding for horses, cattle, and other barnyard animals, except sheep. It can also be used as an absorbent and packing for surgical dressings, as absorption pads for sanitary purposes, for the manufacture of paper and alcohol, and, mixed with molasses, as food for fattening cattle.

MANUFACTURE OF PEAT FUEL IN CANADA

Millions of dollars of public money have been unprofitably spent in Europe, United States, and Canada in testing inventions for manufacturing artificially dried peat fuel. In 1918, a joint Peat Committee was appointed by the Governments of Canada and Ontario to promote the peat industry in Canada by experimenting with and developing the most suitable and successful of air-drying devices. After careful investigations the air-dried process was adopted, and in 1919 the committee erected two improved plants on the Alfred peat bog, near Alfred, Prescott county, Ontario, on the Ottawa-Montreal short line, of the Canadian Pacific railway, 42 miles from Ottawa, to obtain accurate data as to the best plant for use in this country.

A small quantity of briquetted peat is also manufactured by Le Combustible National Limitée at Ste. Therese de Blainville, Que., 20 miles northwest of Montreal. No detailed information is available in reference to the practice followed.

FALLACIES IN REGARD TO DRYING PEAT

Artificial Drying. Many attempts have been made to devise a substitute for air drying but so far they have not been successful. A short comparison of a few of the best known systems is given below.

(*a*) By putting the peat through an artificially heated dryer, through which a strong current of air is driven, thus imitating the natural process of air drying:

A very well drained bog contains on an average 85 per cent moisture, but often a little more. If such a bog be rendered absolutely dry, the product would have a calorific value of 1·8 B.T.U. per pound or 5,400 calories. A drier constructed to utilize 80 per cent of the calorific value of its fuel—if such a drier could be constructed —would require, to evaporate the water from 100 pounds of peat, a consumption represented by the formula,

$$\frac{85 \text{ (per cent of moisture)} \times 640 \text{ (degrees latent heat)}}{0{\cdot}8 \text{ (per cent efficiency)} \times 5{,}400 \text{ (calories of heat per gram of peat)}} =$$

12·4 pounds of dry peat, and the yield would be 15 pounds of dry peat. Even under such nearly ideal conditions, therefore, 100 pounds of wet peat would produce only $2\frac{3}{4}$ pounds of perfectly dry peat.

(*b*) By treating the peat in a vacuum apparatus. If a vacuum apparatus could be constructed capable of vapourizing about 25 pounds of water for every pound of dry peat consumed by it, having a calorific value of 5,400 calories, then from the 12·5 pounds of peat substance contained in 100 pounds of peat pulp having 87·5 per cent of moisture there would be obtained $12{\cdot}5 - \frac{87{\cdot}5}{25}$ or 9 pounds of dry peat, that is, 72 per cent. This would be quite satisfactory, but no such efficient apparatus has been invented; and even if there were such a machine it would be too expensive to operate profitably.

(*c*) Attempts have also been made to remove mechanically, by means of filters, presses, and centrifugal pumps, so much water from the peat that the remaining water could be economically expelled by artificial heat. In rare instances it has been feasible with certain kinds of peat pulp to reduce the water content in this manner

to 65 per cent, but in the majority of cases a reduction to 70 per cent is difficult to obtain. Even if a press could reduce the moisture content to 70 per cent, the cost of fuel for artificial drying would still be too great. For instance, 100 pounds of peat with 70 per cent moisture would require (as in previous calculations) 11 pounds of dry peat for heating the drier. In addition allowance would have to be made for working expenses or depreciation, and for the fuel consumption for mechanical power. Of the 30 pounds of peat substance produced at least half would be consumed in the operation. The centrifugal method for reducing the water content of ordinary peat is even less effective than pressing. Of course if peat so treated contains 70 per cent of moisture and could be dried in a vacuum apparatus, a net output would be available of $30 - \frac{87 \cdot 5}{25} = 26 \cdot 5$ pounds, or 88 per cent of the fuel content of the original peat. This would be a satisfactory result, but as before mentioned not only would it be difficult to bring down the water content to 70 per cent, but no vacuum apparatus of sufficient capacity has been invented.

Peat is composed of gelatinous matter and because of its gelatinous consistency it is difficult to remove the water from peat pulp. It is comparable in this respect to gelatinous silica and alumina. When pulped peat is treated in a filter press a thin layer of gelatinous peat gathers on the surface of the canvas, preventing the water from passing through. If the best humified peat is squeezed in the hand it will be found that the peat squeezes through the fingers, without losing a drop of water.

Experiments have also been carried on with the so-called osmotic method to have the raw peat submitted to mechanical pressure and simultaneously traversed by an electric current parallel to the direction of the pressure which tends to send the water towards the cathode. This method is supposed to destroy the peat cells and render the water more easily expressible from the peat. However, it has been proved that well humified peat is not cellular; for the reason that the vegetable cells of the original plant matter are destroyed by humification.

(*d*) A great deal of money has been spent upon the wet-carbonized system. The raw peat pulp is treated under pressure, to a temperature of 150° C. and even higher, during which time the peat undergoes a two-fold change.

(1) It loses its gelatinous character and becomes amorphous, thus permitting the water to be more readily separated.

(2) It becomes coked or "wet-carbonized" the completeness of which process depends on the temperature used.

Even this system so far has not proved economical and very little has been heard of it during recent years.

AREA OF PEAT LANDS INVESTIGATED IN CANADA

According to R. Chalmers' report on peat,[1] there are in Canada approximately 37,000 square miles of bogs. Since May, 1908, a systematic investigation of the peat bogs has been carried on during the summer months, but only a fraction of this area has been examined.

In Ontario forty-six bogs have been surveyed. These have a total area of 123,321 acres and contain approximately 110,109,000 short tons of peat fuel containing 25 per cent of moisture and 518,000 tons of peat litter containing 20 per cent of moisture.

In Quebec twenty-three bogs with a total area of 76,649 acres have been surveyed. These contain approximately 70,458,000 tons of peat fuel containing 25 per cent moisture and 6,890,000 tons of peat litter containing 20 per cent moisture.

In New Brunswick thirteen bogs have been surveyed. These have a total area of 3,604 acres and contain 499,000 tons of peat fuel (approximately) containing 25 per cent moisture and 2,268,000 tons of peat litter containing 20 per cent moisture.

[1] Chalmers, R., Mineral Resources of Canada, Bull. on Peat. Geol. Surv., Can., 1904.

In Nova Scotia eight bogs have been surveyed. These have a total area of 8,671 acres containing approximately 6,188,000 tons of peat fuel containing 25 per cent moisture, and 453,000 tons of peat litter containing 20 per cent moisture.

In Prince Edward Island six bogs have been surveyed. These have a total area of 5,356 acres containing 1,213,000 tons of peat fuel (approximately) containing 25 per cent moisture, and 1,160,000 tons of peat litter containing 20 per cent moisture.

In Manitoba nine bogs have been surveyed. These have a total area of 6,530 acres containing approximately 1,863,170 tons of peat fuel containing 25 per cent moisture, and 2,553,110 tons of peat litter containing 20 per cent moisture.

Reconnaissance survey has also been made of some large bogs in Manitoba, which aggregate approximately 236,000 acres.

A total of one hundred and five bogs have been fully surveyed with an aggregate area of approximately 224,131 acres. These contain 190,330,170 tons of fuel and 20,588,110 tons of litter containing 20 per cent moisture.

Total reconnaissance survey: number, 9; approximately 236,000 acres.

GOUDREAU GOLD AREA, MICHIPICOTEN DISTRICT, ONTARIO

By Ellis Thomson

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INTRODUCTION

Gold was discovered in this district in 1918, but was at that time considered as of minor importance compared with the pyrite deposits, both because of the smallness of the gold-bearing veins and because of war-demand for pyrite. It was not until the discovery of gold in the Murphy property, township 28, range XXVI, in the spring of 1921, that the district attained any prominence as a possible gold producer.

During the summer of 1921 the district to the east and west of Goudreau was visited by A. G. Burrows of the Ontario Bureau of Mines who made a brief but timely official report[1] on the principal properties.

During the field season of 1921 the writer was given very able assistance by W. F. James and S. H. Davis. Only the former, however, was with him during the examination of the gold properties in the Goudreau district. The writer cannot speak too highly of the assistance rendered by him in that connexion, particularly in working out the detailed geology of claim 408 on Murphy lake.

The writer wishes also to acknowledge the kindness and co-operation of the various residents of Goudreau, whose names are too numerous to mention separately, the hospitality and help extended by Messrs. Brighton, Cline, Webb, and Daimpré, and the very kind assistance rendered by officials of the Algoma Central railway.

LOCATION

The gold-bearing area (Figure 1) is near Goudreau station, on the Algoma Central and Hudson Bay railway, 177 miles north of Sault Ste. Marie and about 17 miles south of Franz, the junction-point of the Algoma Central railway and the Canadian Pacific railway. Gold has been found on both sides of the railway, the older discoveries lying to the east, the newer ones to the west, of the right-of-way. The more important claims may be reached either by canoe route or by wagon road, and are included for the most part in township 28, range XXVI, township 27, range XXVII, and township 26, range XXVII, Algoma district.

TOPOGRAPHY

The contour of this comparatively small area is of the same character as in the rest of the Michipicoten district. Undulating rocky country alternates with marshy ground, and the district is studded with lakes and streams. Most of the water to

1 Burrows, A. G., Can. Min. Jour., vol. XLII, No. 31, Aug. 5, 1921.

the west of Goudreau drains west into Magpie river; the streams and lakes to the east of Goudreau drain south and east into Michipicoten river. The country on either side of the Algoma Central railway has been burnt over at least once, and in several instances, two or three times, and there is little timber except second-growth poplar and birch.

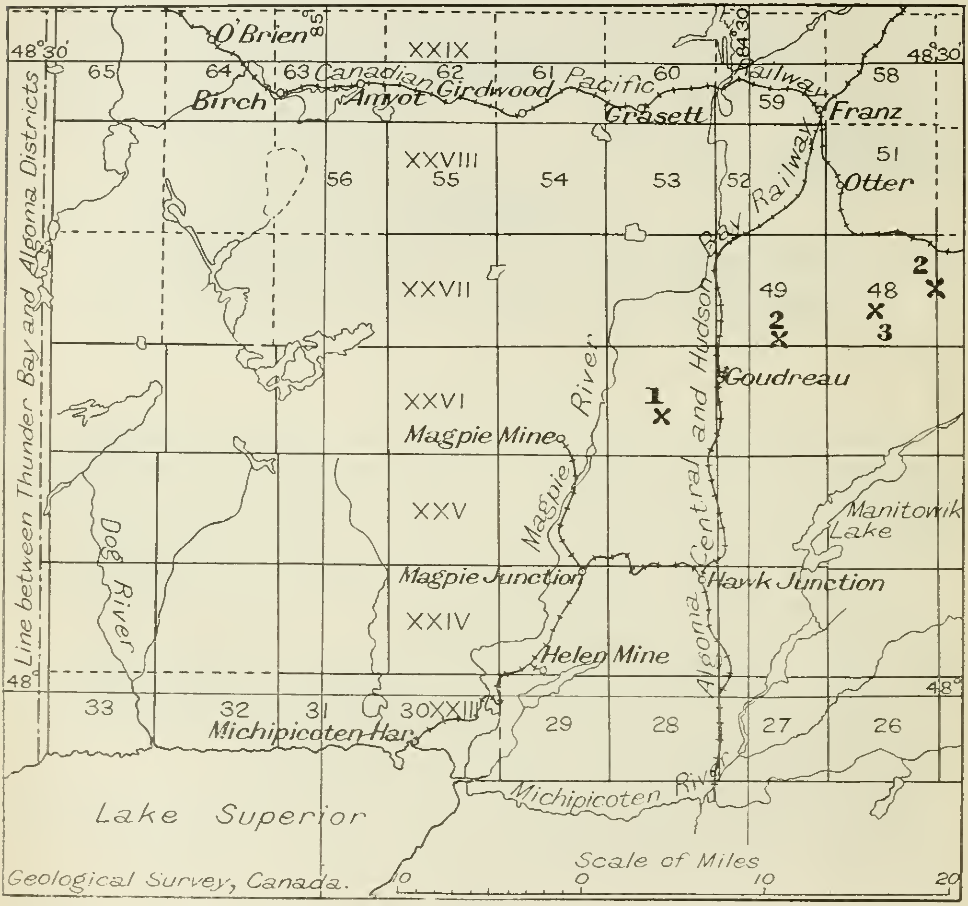

Figure 1. Index map showing location of groups of gold claims in Goudreau area, Algoma district, Ontario. 1, Murphy; 2, McCarthy-Webb; 3, Cline.

GENERAL GEOLOGY

Most of the rocks are acid and basic volumes of the Keewatin formation, but these volcanics have intercalated with them small bands of iron formation and are intruded by a boss of granite. All three of these formations are cut by the diabase dykes of probable Keweenawan age which are so prevalent in this region. The dykes are, in general, younger than the gold ore deposits, the veins being faulted by them in several places. The geological succession is briefly as follows:

Pleistocene deposits of boulder clay, sand, and other loose deposits
Diabase dykes of probable Keweenawan age
Granite
Iron formation
Keewatin volcanics (both acid and basic)

PLEISTOCENE

The Pleistocene deposits are for the most part sand and gravel with smaller amounts of boulder clay. Numerous large boulders suggest old beaches or terraces of lake Superior or its predecessor. Evidence of ice action is not so common here as in some localities, but occasional striæ and morainic material may be observed.

DIABASE DYKES

The diabase dykes are of two distinct types. The first—the younger—usually contains olivine; the second is an older quartz diabase. Both types have already been described[1] in detail, and it is only necessary to add that—as with the pyrite deposits—the gold veins mostly remain unaffected by the intrusion of the olivine diabase dykes, but are sometimes faulted along the fissures occupied by the quartz diabases. These diabase dykes seem to be more prevalent to the east of the Algoma Central railway than they are to the west.

GRANITE

The only boss of granite observed in this area is in the middle of township 28, range XXVI. It is coarse-grained rock, gneissoid in places, and consists chiefly of quartz, orthoclase, plagioclase, and chlorite, with minor amounts of calcite, limonite, and hornblende. It varies in composition from a fine granite to a granodiorite. Locally it is porphyritic and corresponds to a very coarse quartz porphyry. It is close to the best gold-showing in the district and had apparently some connexion with the deposition of the ore. It weathers very readily, showing a characteristic white surface. It is traversed by numerous acid dykes that vary from pegmatites to quartz veins, the latter in some cases carrying free gold and sulphides. The granite intrudes the Keewatin volcanics, but is older than the diabase dykes.

IRON FORMATION

The iron formation has already been described.[2] It differs from the majority of other iron formations in the predominance of the siderite and pyrite members. The bands of iron formation are confined for the most part to the eastern half of the area (Figure 2), but one or two have also been encountered west of the Algoma Central railway. In some places the rocks of this formation have yielded gold values, but principally it would appear from being traversed by small gold-bearing quartz stringers.

KEEWATIN VOLCANICS

These volcanics form 80 or 90 per cent of the rock outcrops. They comprise volcanic flows of two distinct types, acid and basic, and a few occasional flows of an intermediate composition corresponding to andesites or quartz andesites. West of the Algoma Central railway the basic types predominate, but to the east of the right-of-way the acid flows are the more common. For the most part the acid rocks in this locality are older than the iron formations, whereas most of the basic flows are younger than these. Exceptions to this general rule are to be found, however, older basic flows and younger acid flows being encountered in some places.

Basic. The basic Keewatin rocks have already been described[3] and attention will be confined to individual types in which there are gold-bearing veins. These are for the most part fine-grained volcanics with the original texture and composition of a basalt, but so highly altered that their original composition is difficult or

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[1] Collins, W. H., "The Ore Deposits of Goudreau and Magpie-Hawk Areas in Michipicoten District." Geol. Surv., Can., Sum. Rept., 1918, pt. E.

[2] Loc. cit.

[3] Loc. cit.

impossible to determine. In certain instances, when quartz is present they may more properly be classed as quartz andesites. Under the microscope they appear as highly weathered rocks consisting chiefly of altered plagioclase and hornblende, but containing also considerable secondary carbonate and quartz. The quartz occurs chiefly in the form of small stringers, whereas the carbonate appears both in that form and as an alteration product of the other minerals. The feldspars are largely altered to kaolin, sericite, or carbonate, the hornblende in some cases to chlorite. In the vicinity of veins this rock frequently carries biotite, quartz, muscovite, and occasional needles of tourmaline, as a result of the hydrothermal processes accompanying vein intrusion.

In some places the surficial types, amygdaloids, vesicular lavas, and tuffs are prevalent, and in others the fine-grained volcanics give place locally to a coarse-grained basic rock corresponding to an amphibolite. In some places these rocks become porphyritic and although very highly altered their original porphyrite character may be determined.

Acid. As in the case of the basic volcanics only those acid types in which the gold-bearing veins occur need be described. The quartz porphyry and feldspar porphyry types are the important acid flows in this regard, but a felsitic type also carries some gold-bearing veins. An ottrelite porphyry occurs in small amount. These acid rocks are traversed in places by numerous short stringers carrying gold-bearing quartz. The stringers, or veins, are of two types, one following the schistosity of the rock and the other cutting across it.

Structure. According to Collins[1] the rocks of the Keewatin complex in this district have been folded along an axis pointing 60 degrees east of north; and the intrusion of the older Precambrian diabase dykes was connected wth a milder earth movement which resulted in faults of considerable size. The writer has noted likewise that in connexion with the younger Precambrian diabase dykes there has been some movement resulting in places—notably in the Murphy claims—in the very slight displacement of some of the gold-bearing veins.

ECONOMIC GEOLOGY

GOLD

The gold ore carriers in this district are of three distinct types, two of them much more prevalent than the third. The first type is represented by small quartz veins following the lines of schistosity of the Keewatin formations. These veins are sometimes arranged in groups following the shear zones, but are seldom of sufficient width, nor closely enough bunched, to be worth working. For the most part the gangue material is quartz, but occasionally some carbonate accompanies the siliceous matter. Needles of black tourmaline are frequent in veins of this type and occasionally occupy the entire width of the vein. The sulphides, pyrite, pyrrhotite, and chalcopyrite, are to be found, and galena is a very rare constituent. Veins of this kind occur, as a rule, either in the acid volcanic schists or at the contact of an acid and a basic flow, but, in places, they run into the basic rocks. For the most part the acid volcanics are more schistose than the basic rocks and seem to have provided a better opportunity for the formation of the veins. The presence in the acid rocks of more carbonate than in the basic rocks may have been the determining factor in the deposition of the metallic content in the veins, and may explain the greater amount of sulphides contained in the veins cutting the acid rocks. The presence of tourmaline and pyrrhotite, both high temperature minerals, points, apparently, to a pegmatitic origin for these veins. These "shear-veins" are seldom more than a few inches wide nor continuous in length for more than a few feet. The vein-forming solutions have impregnated the wall-rocks on either side for a few inches so that values may be obtained a short distance away from the vein.

[1] Loc. cit.

The second type of vein cuts across the schistosity of the rocks at various angles. This type is found cutting two formations in different parts of the field. East of the Algoma Central railway, veins of this type cut across the acid volcanics of the quartz porphyry and feldspar porphyry types, whereas west of the right-of-way on the claims owned by M. Gutcher, of Goudreau, similar veins cut the granite boss already described.

These two phases of the "cross-vein" type are quite dissimilar and will be discussed separately. The veins cutting the acid volcanics of the Keewatin vary in width from a few inches to 2 feet or more and, in places, as on the McCarthy-Webb property in township 27, range XXVII, they may be traced for 20 or 30 feet. They carry, beside the usual quartz content, pyrite, native gold, and numerous black needles of tourmaline. They are, as noted by Collins, younger than the "shear-veins," and, in places, cut across them. The mineral solutions have not, apparently, impregnated the wall-rock to the same extent as in the case of the "shear-veins." Like the "shear-veins," these veins are, for the most part, neither continuous nor wide enough to exploit. In a few cases several of them may be bunched close together, but the gold values appear to be too uncertain to ensure payable production. Cross-veins of this type are found intersecting the iron formation of the district. Occasionally the iron formation rocks carry gold values which appear, on casual inspection, to come from the iron formation itself, but on closer examination these are found to be due in every case to "cross-veins" or stringers of quartz which vary in width from paper thickness to 3 or 4 inches. These "cross-veins" have not been found of sufficient size to encourage development.

The "cross-veins" cutting the granite boss probably represent the most acid phase of the pegmatite dykes. This type was observed only on the Gutcher claim where the veins are very irregular in width and extent and carry considerable pyrite and covellite as well as a little free gold, chalcopyrite, and muscovite. This type of vein is described in more detail on page 25.

The last type of vein is found only in the Murphy group. This vein is of the fissure type and angles across the strike of both the acid and basic volcanics of the Keewatin series. As it is cut and slightly faulted by a younger diabase dyke its deposition must have preceded the intrusion of these dykes.

The prevalence of tourmaline in all these types suggests that the gold-bearing solutions were an integral part of the last juices of the granite magma. The fact that the Keewatin rocks in this district are surrounded by granite, and the appearance of a small granite boss near the Murphy claims, indicate that granite underlies a comparatively shallow covering of older Keewatin rocks. If this be the case, the injection of pegmatitic mineralized solutions into the cracks and fissures of the overlying Keewatin rocks would be a natural consequence of the last stages of cooling of the granite magma. The presence of tourmaline in most of these veins supports this theory. The metallics pyrrhotite and chalcopyrite might also be expected under such conditions. That native gold has been found on the Gutcher claim in quartzose veins of the pegmatite type, cutting the boss of granite, shows that gold-bearing solutions were not foreign to the granite body itself.

Description of Properties

McCormick. This property, SSM 2183, is situated in township 26, range XXVII, east of Pine lake. A fairly good wagon-road runs from Goudreau station to the east end of Pine lake, whence a very good trail leads to this and adjoining claims. An alternative route is by wagon-road to Teare lake and thence by lake and portage to the east end of Pine lake where the aforementioned trail may be picked up. A shallow pit about 9 feet deep has been sunk on the band of iron formation in basic Keewatin volcanics, with a strike of 70 degrees and a dip of 70 degrees to the north. This band, which is from 2½ to 4 feet in width and about 70 feet long, carries considerable amounts of pyrrhotite and quartz as well as minor amounts of chalco-

pyrite, pyrite, sphalerite, and carbonate. Gold values at the shaft are said to vary from $46.60 on the surface to $19.20 at a depth of 4 feet. No values of consequence have been obtained from other parts of the band.

Fuller-Black SSM 2184. This property adjoins the McCormick on the west. At the contact between acid and basic Keewatin flows, at a point near the south boundary of this claim, a small quartz stringer carries pyrrhotite, chalcopyrite, and pyrite, as well as some free gold. The acid rock, which is a quartz porphyry, lies to the north, and the basic rock to the south. The rocks and the vein strike at 107 degrees and vary in dip from 70 degrees to the north to vertical. The basic Keewatin carries considerable pyrite and has a rusted appearance 15 or 20 feet south from the contact. Values of $25 a ton in gold are reported to have been obtained from this stringer.

Cline, SSM 2185. This claim is north of 2183 and east of 2184. It is owned by J. P. Cline, of Goudreau. The gold values here have been found in a band of sulphide-bearing basic Keewatin volcanic at the contact with the acid quartz porphyry, both rocks striking east and west and having a vertical dip. This band is said to carry values in gold up to $6.

Cline, SSM 2186. This claim adjoins 2185 on the east. Four small pits have been sunk, three close to the western boundary and the fourth near the centre of the claim. The first is a shallow depression where a few shots have been put in after stripping. Here a narrow band of acid Keewatin volcanic from 8 inches to 3 feet in width, shot through with small "shear-veins" and "cross-veins" of quartz carrying pyrite, pyrrhotite, tourmaline, and a little native gold, is intercalated in the basic Keewatin rocks. This band has a strike of 105 degrees and a vertical dip. Gold values at this point are said to range from $5 to $150 a ton.

About 200 feet east of this is another shallow pit, sunk on a quartz vein 6 inches to 1 foot wide, with a schisted zone 4 feet wide, carrying smaller "cross-stringers" next to the foot-wall. The vein strikes east and west and dips at an angle of 75 to 80 degrees to the north. The wall-rock is basic Keewatin. The vein carries much the same metallic constituents as at the first pit and shows gold values which are said to range from $22 to $24 a ton.

At the last pit a 10-foot hole has been sunk on a quartz vein 2 inches to 1 foot wide, with a schisted zone 2 to 3 feet wide immediately south of the vein. The country rock on either side is a coarse basic Keewatin volcanic. The vein, which carries pyrite, pyrrhotite, magnetite, and a little free gold, strikes east and west and dips 85 degrees to the north. Free gold has been found for about 35 feet along this vein, which has a total length of about 50 feet, but average samples have not been taken. Grab samples are said to have given high values. Pit No. 3 is about 100 feet north of the second pit and is sunk on a composite quartz vein, 20 to 30 inches wide, with a strike of 118 degrees and a dip of 70 degrees to the north. This vein, which parallels the schistosity of the basic Keewatin through which it runs, carries pyrite, magnetite, and tourmaline. A more solid band of quartz near the foot-wall carries the gold values, which are not high. A sample taken by Collins in 1919 from a vein 10 inches wide which lies about half-way across the claim and 300 feet north of the trail, was assayed by the Department of Mines and found to contain $1.20 of gold a ton.

Cline, SSM 2189. This claim is one claim east and one claim south of SSM 2186. Close to its northeast corner a pit 25 feet deep has been sunk on some small quartz stringers, samples from which are said to have yielded very high values in gold. These stringers cut the basic Keewatin rocks for the most part, but also a narrow acid flow to a minor degree. Both flows, which strike east and west and have a vertical dip, are cut by a younger diabase dyke with a strike of 165 degrees.

Webb, SSM 2470. This property, which is owned by Joseph Webb of Sault Ste. Marie, is situated near the east end of Godin lake in township 25, range XXVII, near

the line between townships 25 and 26. It may be conveniently reached by water-route from Lochalsh, a station on the Canadian Pacific railway east of Franz; or less easily by a continuation of the same route by which the Cline claims are reached from Goudreau. The country has been recently burnt over in that vicinity so that the rocks are well exposed in most places. The gold values have been found in a band of discontinuous "shear-veins" occurring in the schistosity planes of the basic Keewatin rocks. These rocks have a strike of 100 degrees and a vertical dip. This band is said to extend for 1,700 feet, but only 200 to 300 feet of it was seen by the writer. The stringers vary in width from a few inches to 6 or 10 feet and there are some "cross-stringers" cutting them in places. Gold values have been obtained from this band, which carries some pyrite. At a small pit east of the main showing, a composite vein of quartz and basic Keewatin rock, with a width of about 6 feet, carries considerable carbonate. The country rock here also is basic Keewatin.

Webb-McCarthy, SSM 2049 and 2050. These claims are owned by Joseph Webb and D. J. McCarthy, of Sault Ste. Marie, and are situated near the south boundary of township 27, range XXVI, on the north shore of Iron or Webb lake. The gold showings are in an acid Keewatin flow, which occupies the north half of the claims, and which is in contact with a basic flow to the south. This acid volcanic corresponds to a highly silicified quartz porphyry schist and is seamed with numerous "shear-veins" and "cross-veins" which carry the gold. The schist strikes about east and west and has a dip of 70 to 80 degrees to the north. The contact between the two flows, however, runs to the south slightly, and the veins on the adjoining claim to the west (2051) are also to be found in the same acid flow. Neither the "shear-veins" nor the "cross-veins" which intersect this flow are continuous for any considerable distance, 200 feet being the maximum, the width varying from 2 inches to 16 inches. Both types of vein carry considerable black tourmaline as well as some pyrite and free gold In one or two of the "shear-veins" tourmaline occupies the entire width of the vein. The rock itself is in many places impregnated, a short distance from the vein, with both pyrite and tourmaline. The "shear-veins" are about twice as numerous as the "cross-veins". At the contact of the two flows a small vein shows exceptionally high values in gold. Most of the showings of free gold are on claim 2050. Just east of the west boundary of 2049 an olivine diabase dyke outcrops, and no showings were observed east of this dyke.

Webb-McCarthy, SSM 2051. No work of consequence has been done on these claims since Collins described them. They occur in the same acid flow as those on 2049 and 2050. The "cross-veins" are rather larger and contain considerable black tourmaline.

This set of three claims is readily accessible by road and trail or by road and canoe-route from Goudreau station.

Banville-Pagé. Claim 532 owned by J. Banville and O. Pagé is situated on the north shore of Rowan lake in the middle of township 28, range XXVI (Figure 2) and west of the Algoma Central railway. All those previously described lie several miles east of the railway (Figure 1). A fair wagon road runs from Goudreau station to the Murphy claims passing along the south shore of Rowan lake, from where a canoe or boat must be taken to the claim. An alternative route is by canoe through a string of lakes and portages. Gold has been found on this claim in a contorted band of iron formation cut by numerous "cross-stringers" of quartz. The iron formation consists chiefly of carbonate and quartz. The country rock is a basic Keewatin schist, with a strike of 105 degrees and a vertical dip. The "cross-stringers" contain a little chalcopyrite as well as occasional flakes of gold, a few "shear-veins" were observed in the country rock. The iron formation is only 6 to 10 feet in width, and is contorted locally in the form of an overturned fold, with the axis of the fold pointing northwest. A 6-foot pit has been sunk on this band.

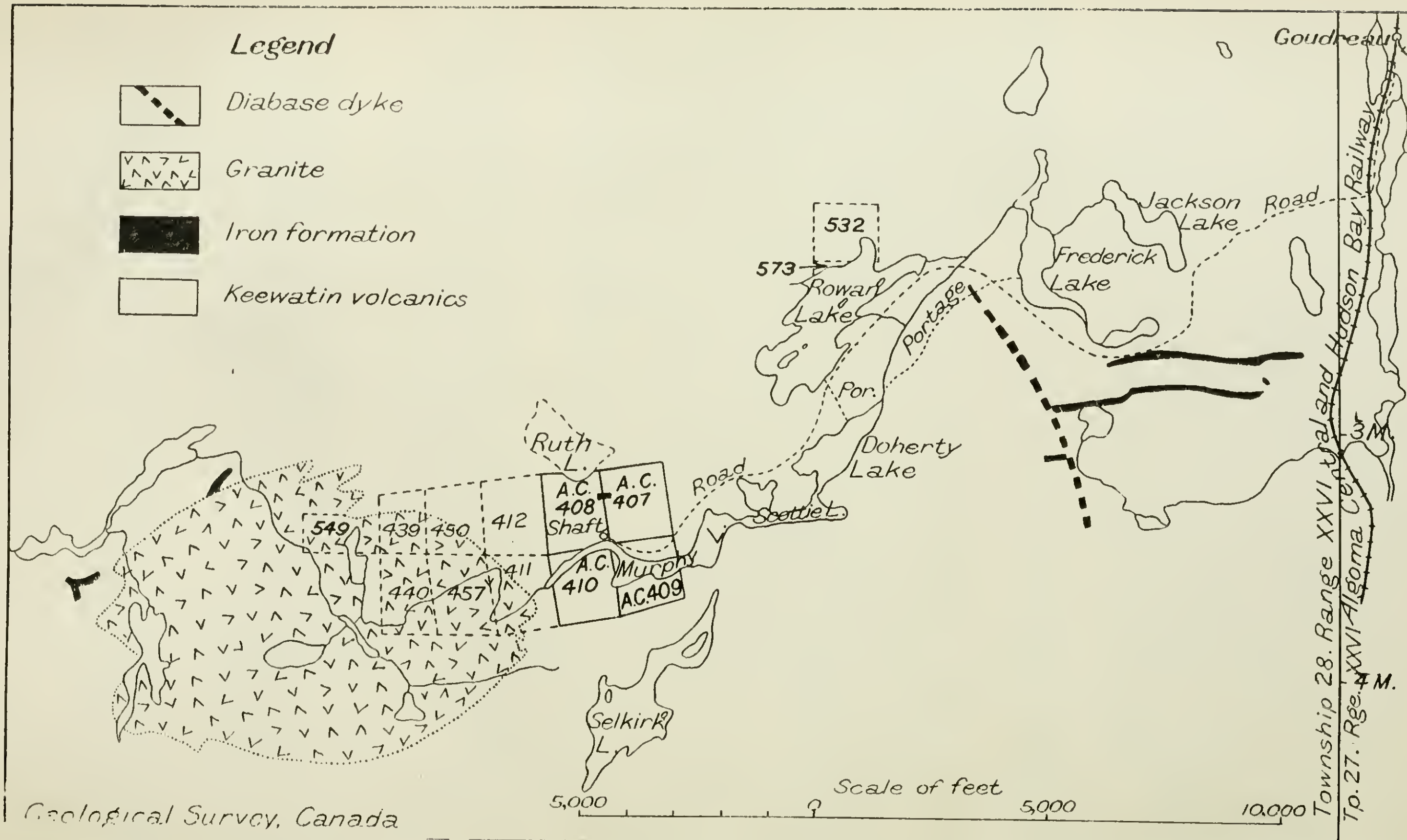


Figure 2. Diagram showing location of Murphy claims (A.C. 407-410), Banville claims (573 and 532), and Gutcher claim (549), Goudreau area, Algoma district, Ontario. Note: Claims shown by broken line are unsurveyed.

Gutcher, SSM 549. This property, which is in township 28, range XXVI, lies west of, and is connected by trail with, the Murphy claim. The granite boss already mentioned outcrops on this claim and the gold-bearing veins are evidently quartzose phases of pegmatitic dykes representing the last stages of cooling and differentiation of the granite magma. The granite shows gneissoid structure in places and in others merges into a coarse quartz porphyry. The veins cutting the granite have been classed with the "cross-veins" for the sake of convenience, although they do not show the same characteristics as the "cross-veins" cutting the Keewatin volcanics. Gold has been found in a quartz vein 1 to 3 feet wide carrying considerable pyrite, covellite, and muscovite, as well as some little chalcopyrite, malachite, and ankerite. This vein has a strike of approximately 125 degrees and dips at an angle of 70 degrees to the north. It has been traced for 200 feet and in one or two places has side stringers. A larger quartz vein a short distance away in the same kind of rock has a maximum width of 12 feet, but, so far as the writer was able to observe, carries no values.

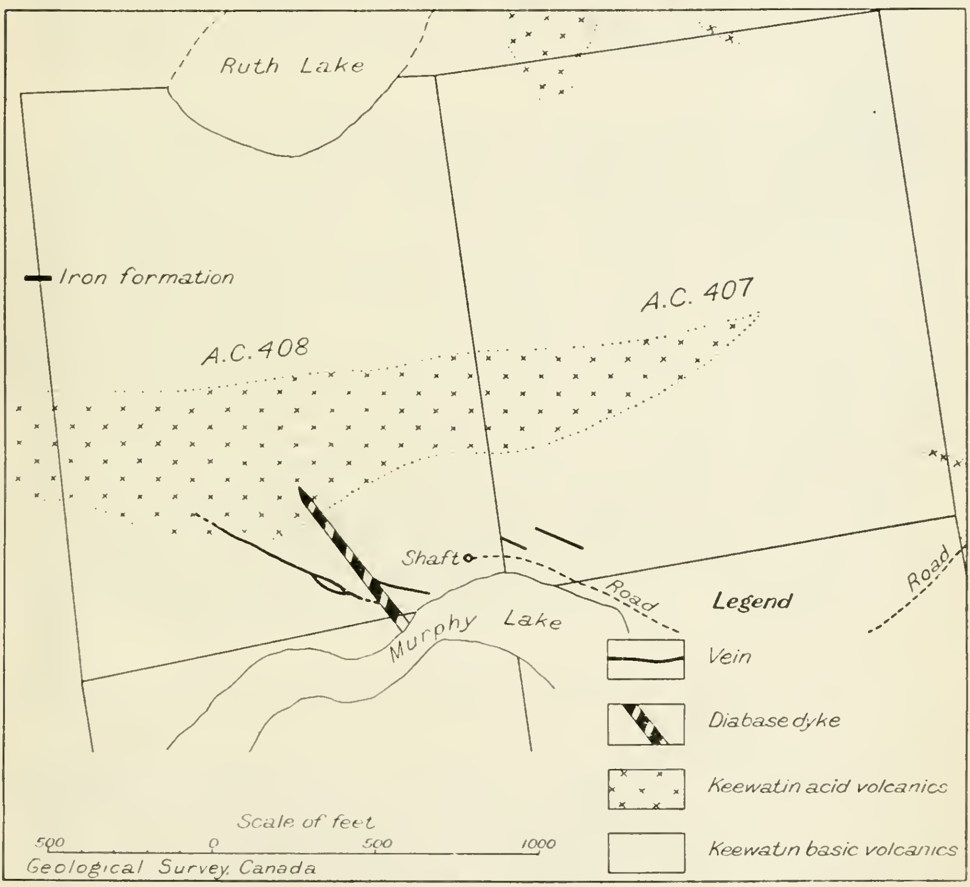


Figure 3. Diagram showing geology of Murphy claims, A.C. 407 and A.C. 408, Goudreau area, Algoma district, Ontario.

Murphy Claims. In township 28, range XXVI, on the north shore of Murphy lake, a group of four claims, 407 to 410, were staked by Thomas Murphy and James Perry, of Goudreau. The first discovery was made in a quartz vein in claim No. 408 where quite coarse gold was found at several places in a distance of 20 feet. In the month of September these claims were surveyed. A fair wagon road connects these claims with Goudreau station, 5 or 6 miles distant. An alternative route is by a string of lakes and portages. Most of the work has been done on 408, in the south-east corner, where the best gold showings have been found. Several acres of ground

have been cleared and the vein has been stripped for its entire length and sunk on for 20 feet. Although the vein is confined chiefly to 408, small stringers are found in the adjoining claim 407. The main vein has a strike varying from east and west to 295 degrees and a dip from 60 degrees to the south to vertical. It has been traced for about 800 feet, with a width of from 1 to 10 feet. Its country rock is for the most part basic Keewatin, but it intersects an acid flow toward its western end, both with a strike of about 100 degrees and a vertical dip. The gangue material is chiefly quartz with numerous small needles of tourmaline which give it a black colour. The metallics are for the most part native gold, pyrrhotite, and chalcopyrite, but appreciable amounts of bornite, pyrite, and sphalerite are also found. Running parallel with the vein for a considerable distance, and occupying part of the same fissure, is a band of carbonate iron formation which weathers on the surface to limonite. The country rock for about a foot on either side of the vein has been largely impregnated with quartz and the metallic constituents of the vein. At one point the vein has been offset 76 feet on a bearing of 230 degrees by a younger diabase dyke about 50 feet wide, which strikes at 140 degrees. Native gold has been found at numerous places along the vein and a good showing was noted by the writer at the bottom of the 20-foot shaft.

Regarding another vein, Mr. Burrows reports as follows in his preliminary report issued last summer. Work has also been done on claim 407 to the east. At the west line, 200 feet north of Murphy lake, a narrow quartz vein about a foot in width has been traced 65 feet; it strikes south 80 degrees east. The wall-rock for a few inches is quite rusty and carries sulphides. Visible gold was observed at two points along the vein. About 200 feet easterly from the west line work has been done on a wide ankerite-schist band up to 20 feet in width, which carries quartz veins roughly parallel with the ankerite band. It has been traced for 170 feet in a direction south 70 degrees east. No visible gold was observed in this vein, but at one point an assay of $6 in gold was obtained over a width of 2 feet 9 inches of quartz and $4 in gold over a width of 5½ feet of the schist and carbonate, carrying quartz, lying to the north. Owing to the highly altered character of the schist by oxidation, the latter assay is only indicative of the presence of gold which may be concentrated. The quartz vein carries pyrite, copper pyrites, pyrrhotite, and a little zinc blende. It is possible that this easterly vein is the faulted part of the vein exposed on claim 408.

These four claims were worked on option during the summer of 1921 by A. R. Porter, Toronto, but later the property was taken over by a group of Toronto men. Claim 408 appears to be much the most promising in the district and the only one where the vein holds its values for more than a few feet. Being of the fissure type, the values probably hold at depth. Considerable native gold was located at the 20-foot level.

The writer has purposely confined his descriptions to those claims showing gold, and has made no mention of the numerous other properties that have been exploited in the hope of getting values.

On the way back to Toronto the writer stopped at Bruce Mines, at the request of Daniel MacDonald of that place, to examine a gold prospect in the greywacke formation. The gold was discovered in the bed of Thessalon river in the southwest quarter of section 9, Lefroy township, Algoma district, in a loose boulder of greywacke of the Gowganda formation. It occurs in small quartz veins following the joint planes in the rock. The boulder is said to be angular in outline and consequently unlikely to have travelled far, but at the time of the writer's visit was under water. The quartz stringers were very small, seldom exceeding one-half inch in width. The big fault which runs easterly through this section of the country is located in the bed of the river at this point and the movement which produced it may have shattered the neighbouring greywacke formation for the reception of these tiny veins. Diabase sills are in fairly close proximity, and these are known to have been the cause of gold-bearing veins, such as occur at the Havilah mine, about 10 miles north of the locality where this boulder occurs.

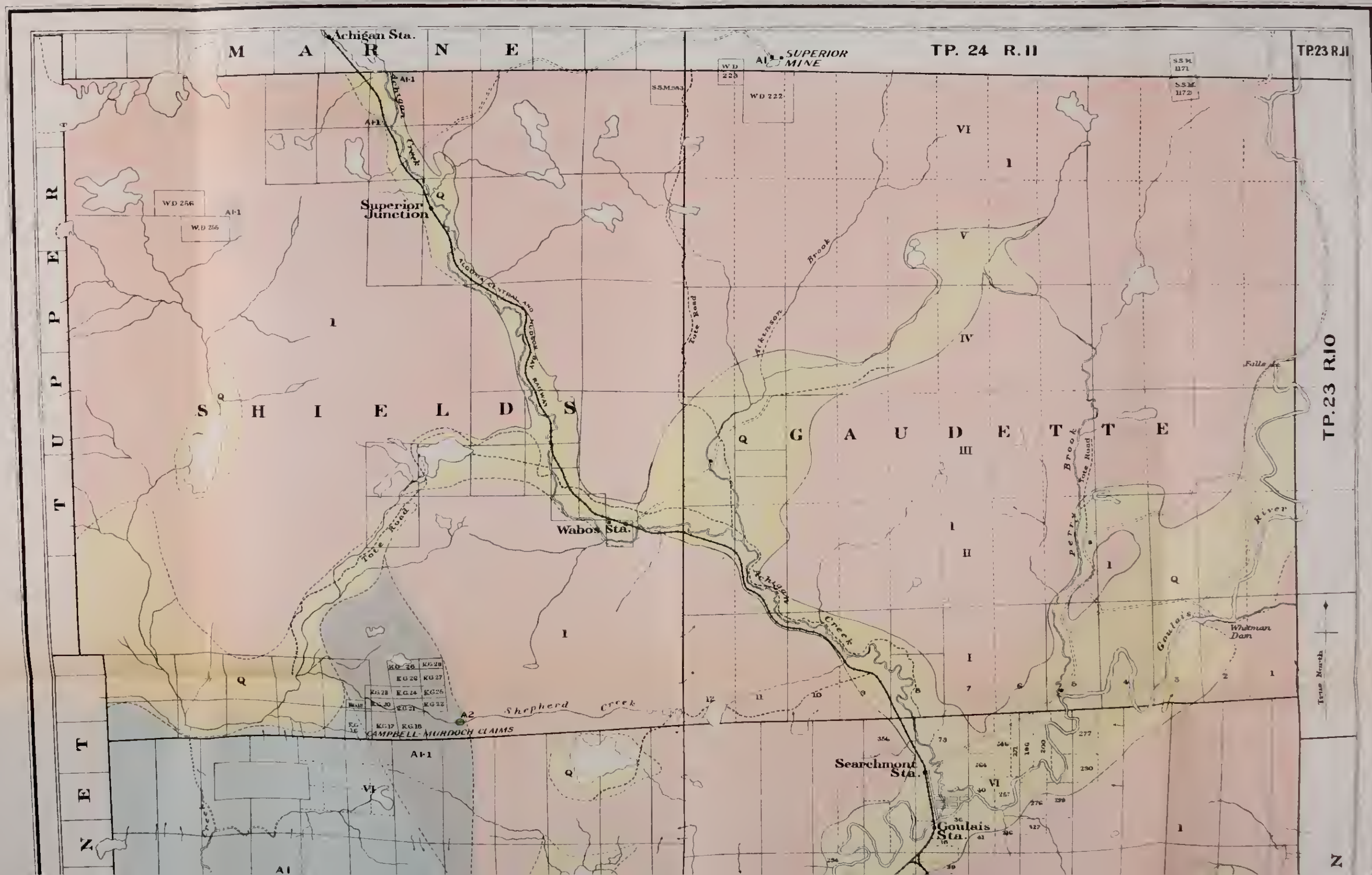
Canada
Department of Mines

HON CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY

W.H COLLINS, DIRECTOR

Issued 1922



LEGEND

QUATERNARY — PLEISTOCENE AND RECENT — Q — Glacial drift and stratified lake deposits

HURONIAN — KEWEENAWAN — 2 — Diabase

COBALT SERIES — A3 — Lorrain quartzite

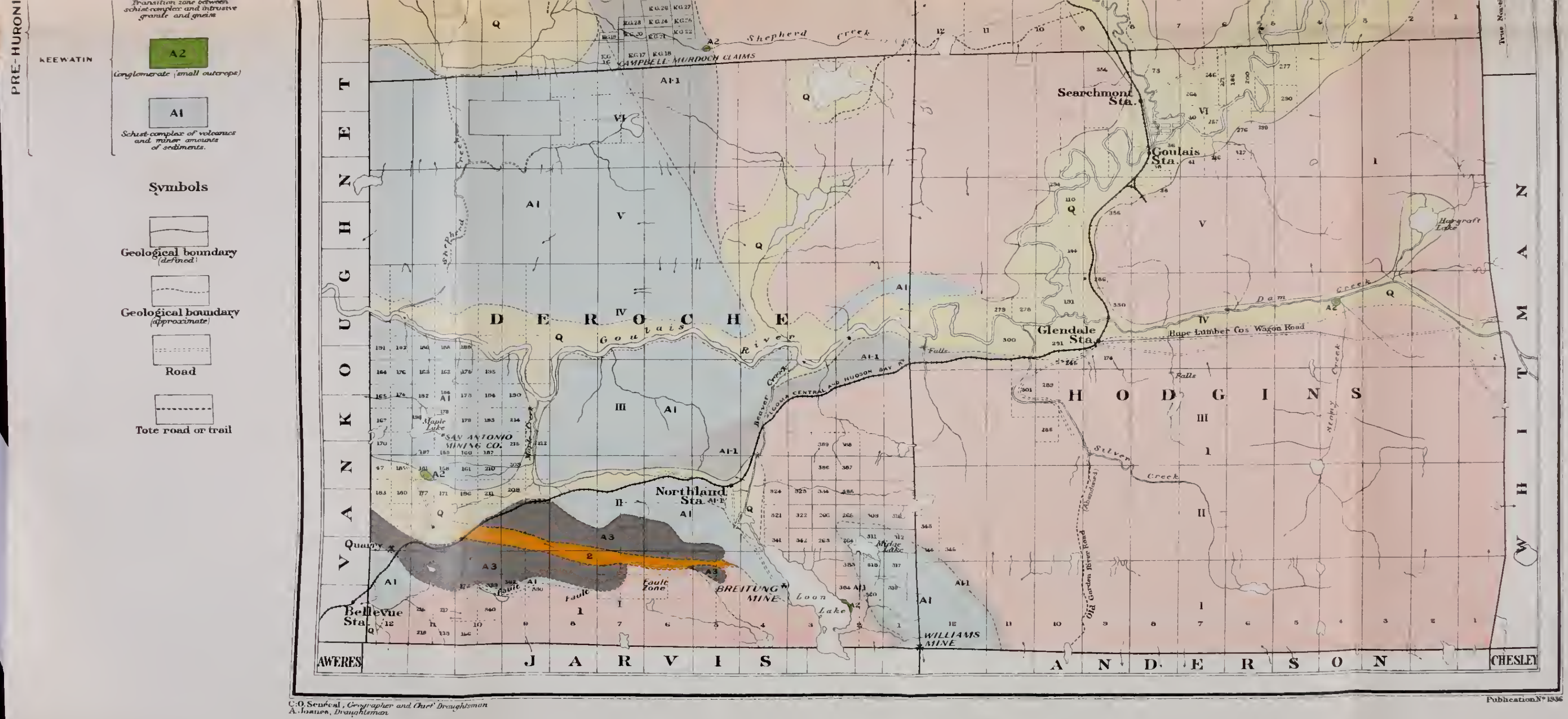
PRE-HURONIAN — BATHOLITHIC INTRUSIVES — 1 — Granite and gneiss

KEEWATIN — A1-1 — Transition zone between schist-complex and intrusive granite and gneiss

A2 — Conglomerate (small outcrops)

A1 — Schist-complex of volcanics and minor amounts of sediments.

Symbols



SHIELDS, GAUDETTE, DEROCHE, AND HODGINS TOWNSHIPS, ALGOMA DISTRICT, ONTARIO.

Scale of Miles

Sources of Information

Geology by Sir S. Brunton, 1921
Basemap from plans of surveys by the Department of Lands and Forests, Ontario, and the Algoma Central and Hudson Bay Railway.
Map compilation by A. Joanes.

To accompany Report by Sir S. Brunton in Summary Report, Part D, 1921.

DEROCHE, HODGINS, GAUDETTE, AND SHIELDS TOWNSHIPS, ALGOMA DISTRICT, ONTARIO

By Sir Stopford Brunton

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INTRODUCTION

For many years iron ore has been reported from various places on the line of the Algoma Central railway, and a considerable amount of prospecting has been done from time to time. Some of these ore outcrops have attracted attention lately, and the writer was detailed by the Geological Survey to investigate and map geologically an area comprising the townships of Deroche, Hodgins, Gaudette, and Shields, to determine the nature and extent of any occurrences of iron ore which might be found.

Two months were spent in the area, during which the writer was assisted by Mr. Walter J. Kingsmill, and during one month the party was augmented by F. Wright and Mr. G. Bain. Mr. G. S. Cowie, secretary of the Mines Department of the Algoma Steel Corporation, also assisted materially and is deserving of many thanks.

GENERAL CHARACTER OF THE AREA

The area is situated on the Algoma Central railway about 20 miles north of Sault Ste. Marie, Ont. Travel away from the railway is difficult as there are no streams on which a canoe can be used, and only one or two roads. A good road runs from the Sault to Bellevue at the southwestern limit of the area, and another is being built from Wabos to Glendale with the ultimate intention of connecting the district with the Sault either via Bellevue or by the old Garden River road, which has been abandoned for fifteen or twenty years and is at present impassable.

The country taken as a whole is one of comparatively low relief, the hilltops reaching about 1,500 feet above sea-level. The difference of elevation between the hills and valleys is 400 to 500 feet, and the hillsides are steep, rendering any passage through the area difficult. Nobody lives in the district except along the railway line and in a few of the valleys closely adjoining it. The area has been burned in places and lumbered over, so that a large part is covered with berry bushes and second growth. There are a few lakes, all too small and disconnected for canoe work, and the streams are mere rivulets over falls, and are dry, or almost dry, in summer.

GENERAL GEOLOGY

The rocks can be classified under the following divisions:

Pleistocene	Lake and glacial deposits
Keweenawan	Diabase dykes
Huronian	Lorrain quartzite
Pre-Huronian	Granite complex Schist complex consisting of volcanics and some associated sedimentary materials

PRE-HURONIAN SCHIST COMPLEX

The Pre-Huronian complex is a very involved mixture of schists, including hornblende schist, diorite, diabase, and even more basic rocks invaded and metamorphosed by batholithic masses of granite and gneiss. The schists underlie the southwestern part of the area, and consist of volcanic flows and tuffs, with some interbedded conglomerate. They have been dislocated and metamorphosed to such an extent that a detailed separation was not possible in the time available. The volcanic element of the series, in some places shows distinct bedding and very fine texture as if it had been laid down under water, in others it shows vesicular structure, and yet in others volcanic bombs are clearly discernible. The strike and dip vary greatly; the strike varies from north 70 degrees west to north 55 degrees east and the dip from about 20 degrees to almost vertical; there appears to be no system in the strike and dip, and the rocks seem to lie anyhow.

Some of the outcrops may be described in greater detail. On the road to the San Antonio Mine Company's house at Maple lake is an agglomerate consisting of aggregates of quartz and feldspar crystals, both orthoclase and plagioclase, in a groundmass composed of fine-grained fragments.

Near Midge lake a fine-grained mass of uniform texture is composed for the most part of chlorite. In the hand specimen thin bands can be distinguished and these also appear in the thin section showing a difference in composition, for whereas one band is for the most part chlorite another is made up chiefly of quartz grains.

A short distance from the outlet of Midge lake another type can be seen, namely a porphyrite having large phenocrysts of hornblende enclosed in a cryptocrystalline groundmass, the whole highly impregnated with iron so that the rock has a bright red appearance.

The occasional interbedded conglomerates are formed of a matrix of fine-grained material containing pebbles, mostly of granite, ranging up to 6 inches or 8 inches in diameter. These beds are not regular nor do they run continuously for any great distance, nor have they the appearance of basal conglomerates. Outcrops were found to the north of the Algoma Steel Corporation's quarry in Vankoughnet township, on the eastern edge of Loon lake, at the junction of Dam creek with Stony creek, and in the eastern branch of Shepherd creek near the Campbell Murdoch claims; in the two last-mentioned places the conglomerate showed evidences of crushing and faulting. Both the volcanics and sediments show signs of contact metamorphism, and are cut by dykes of fine-grained granite.

GRANITE

Although there is only one colour used upon the map to indicate granite, there are probably two granites of different ages in the district. The granite underlying the whole southern part of the area is different from the granite north of Goulais river, in that it does not contain inclusions of hornblende, schist, etc.; and is of a comparatively uniform composition over an area comprising the southern part of Deroche and the northern half at any rate of Jarvis. This part of the area has a distinctive physiographic relief, for whereas the ridges formed of the Pre-Huronian volcanics and sediments, and even those formed of the Huronian quartzites, have a well-marked northwest-southeast trend, the granite has no such features, but is composed of small hummocks with intervening depressions, in which the water flows in all directions indiscriminately. Dykes of granite have been found cutting the Huronian sediments.

A specimen of granite from the north bank of Goulais river is white and fine-grained; in places this rock has been so much deformed as to lose all the normal characteristics of granite. The thin section shows mostly quartz and feldspar, both orthoclase and plagioclase, and an almost entire absence of ferromagnesian minerals with the exception of a little mica and some accessory epidote. The grains are all crushed and broken, the feldspars are deformed, and all the grains show strain shadows, as if the rock had been subjected to great stresses. On the other hand two specimens from just south of the Goulais are composed of pink feldspar and much ferromagnesian mineral. The thin section shows quartz orthoclase, microcline, biotite, leucoxene, horn-

blende, and accessory apatite. The rock is entirely unaltered and shows no signs of fracturing or strain shadows. It is doubtful if specimens with such different characters both of composition and structure represent the same rock. The southern granite is in part at least younger than the Pre-Huronian volcanics and sediments and may even be intrusive into the Huronian; in other words it is probably allied to the Killarney granite.[1]

HURONIAN

Near Bellevue is a small area 3½ miles long and from ½ to 1 mile wide, underlain by Huronian rocks, which Collins considers to be the Lorrain quartzite of the Cobalt series. This quartzite, varying from fine to coarse-grained beds, contains pebbles up to 2 or 3 inches in diameter. These pebbles are for the most part granite, but there are many of bright red jasper. The texture of the rock varies from a hard siliceous quartzite to soft beds of sericitic sandstone which show very fine ripple-marks and evidences of shallow water or subaerial deposition; from the peculiar appearance of some of the beds Mr. Kindle concludes that they originally contained oolitic grains which have since been leached away. The beds strike fairly uniformly north 70 degrees to 75 degrees west, but the dip varies between 35 degrees and 75 degrees north. They lie unconformably upon the Pre-Huronian volcanics and sediments, and are cut off, to the south and southeast by the granite, to the north and northwest by the Pre-Huronian. Near mile 20 on the Algoma Central railway there is a quarry belonging to Wright and Company, from which the Algoma Steel Corporation get a supply for their furnaces at the Sault. Approximately 10,000 tons were quarried last year and the same quantity is expected for this year. An average sample analysis from several carloads gave: silica, 96·55 per cent; iron, 2·57 per cent; alumina, 0·61 per cent; lime, 0·41 per cent; but several analyses ran 98 per cent silica or even higher. A specimen from this quarry shows in thin section a rock almost entirely composed of silica grains 1 to 2 millimetres in diameter, very angular and showing strain shadows. In the quartzite beds are several cracks filled with a fine-grained red detritus carrying angular fragments of breccia. Veins of specular hematite, also, cut the quartzite.

Records of diamond drilling on mining prospects occupying lots 6 and 7, concession II, Deroche township, are as follows:

"*Diamond Drill Exploration, Hawkshaw-Derrer Property, near Northland Station, A.C.R. Township of Deroche*

Drilling of Claims Nos. SSM 1070, SSM 103, Lots 6 and 7

No. 1 Jan. 11, 1910			No. 2 Feb. 8, 1910			No. 3 Mar. 11, 1910		
from	to		from	to		from	to	
0 ft.	19 ft.	Casing	0 ft.	35 ft.	Casing	0 ft.	42½ ft.	Casing
19	208	Quartzite	35	252½	Quartzite	42½	50	Greywacke
						50	63	Quartzite and greywacke
						63	69	Slate and quartzite
						69	73	Quartzite
						73	123	Slate
						123	224	Slate and quartzite Banded
						224	260	Quartzite and slate
						260	267½	Quartzite
						267½	274	Quartzite
						274	330	Slate and quartzite
						330	402	Banded quartzite, slate, and greywacke
							402	Mixed
						402		5 inches hematite
						402	410	? ? ?
						410	470	Quartzite and slate

NOTE. No ore shown on this property by diamond drilling."

[1] Geol. Surv., Can., Sum. Rept., 1920, pt. D.
Geol. Surv., Can., Mus. Bulls. Nos. 8 and 22.

The names are copied from the engineer's blueprint, but no examination could be made of the cores and what has been classed as greywacke is probably Pre-Huronian volcanic rock.

DIABASE DYKES

The whole area is intersected by diabase dykes in all directions. This conforms very closely to the description given by Collins of the diabase dykes in Goudreau and Magpie-Hawk areas.[1] These dykes are of two varieties: (1) a quartz diabase such as the large dyke running from the quarry near Bellevue to Loon lake; and (2) an entirely quartz-free diabase which is found cutting the granite in the southern part of the area. As in the Goudreau area, so in the Deroche area, some of the quartz diabases are very hard to distinguish from the Pre-Huronian greenstones, and are in many places sheared and faulted. The quartz-free diabase is much fresher in appearance and shows none of the shearing referred to in the quartz diabases.

PLEISTOCENE

Lying unconformably upon the Precambian are deposits of Pleistocene clays, sands, and gravels, which in some cases have been laid down in rivers and lake bottoms, but in others are due to morainal action. Several terraces can clearly be distinguished: at Ed. Pognant's house near mile 20 there is a considerable stretch of one of these terraces (elevation 1,115 feet by aneroid barometer) to the north of the railway track, and just south of the track is another terrace (1,175 feet, aneroid). A succession of terraces occur up Goulais river from Searchmont to the Falls at elevations of 835 and 855 feet, each terrace being distinctly defined. Near Wabos station are two terraces, 962 and 973 feet respectively.

Along the banks of Goulais river near Bellevue the deposits are of clay, sometimes attaining a thickness of 50 feet, and fine sand. Crossbedding and minor unconformities can be seen in the cuttings along the railway. Towards the north, however, a change takes place and the deposits along Achigan creek are composed of coarser sand carrying pebbles and boulders intermixed, showing the characteristics of morainal origin.

FAULTING AND FOLDING

The Goulais valley is a very striking physiographic feature, running as it does for nearly 12 miles in a straight line. North of it, though not so apparent, owing to its greater inaccessibility, is a parallel valley along which runs the east branch of Shepherd creek. At the junction of Dam creek (which is simply the continuation of the Goulais) and Stony creek, the rocks show evidence of faulting, and the granites near Searchmont show similar evidence of severe deformation. The big diabase dyke which runs parallel to the Goulais just south of the railway is possibly associated with this movement. Loon lake, also, occupies a fault zone, granite occurring on the east side and steeply tilted volcanics on the west. The trend of this zone is northwest-southeast.

There are, probably, at least two systems of faulting: an east-west system which controls the valley of Goulais river, and a northwest-southeast system which seems to be more recent than the east-west, as the diabase dyke parallel to the Goulais is cut off at Loon lake and deformed and all the east-west veins on Mr. Mason's prospect are cut by the northwest-southeast veins which are continuous.

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[1] Geol. Surv., Can., Sum. Rept., 1918, pt. E.

ECONOMIC GEOLOGY

IRON ORES

The occurrences of iron ore in Deroche and adjoining townships differ considerably from the deposits of ore known as iron formation. Those in Deroche township consist for the most part of hematite and specularite associated with quartz veins which cut the Pre-Huronian volcanics. Those in Shields have much more the appearance of chemical precipitates.

Two properties have been developed to a point at which they can be designated as mines, but neither is now in operation. The Breitung mine was opened up twenty-two years ago, and ore was shipped to Northland on a switch-line built from the Algoma Central railway. The Breitung Iron Mining Company, Marquette, Mich., now owns the property. The ore-body lies in the side of a steep hill about 300 feet high, half-way down the west side of Loon lake. Two adits were driven into the hill, one about 80 feet above the lake, the other about 75 feet still higher. An open pit, a shaft, and a few shallow workings may be seen about 200 feet above the lake. The wreckage of a small steam winding plant lies at the foot of the hill.

The rock at the mine is a slate-coloured, finely bedded greywacke, sharply folded and evidently of pre-Huronian age. The ore-body occupies a zone which has been fractured and shattered into a breccia and afterwards recemented with quartz and specular hematite. In most places there does not seem to be more than 10 or 15 per cent of metallic iron present, but locally where brecciation was most intense the iron oxide has either penetrated in larger amount, or has chemically replaced part of the greywacke, yielding a low-grade ore carrying possibly 30 or 40 per cent of iron. Apparently it was these rich spots that induced mining operations. The better-looking material is limited at the shaft to a width of about 30 feet, but leaner mineralization occurs almost to the foot of the hill. The general trend of the mineralized belt appears to be nearly parallel to the length of the lake.

The Williams mine is situated at the corner of the four townships Deroche, Hodgins, Jarvis, and Anderson, about 1½ miles east of the southern end of Loon lake. The property was first located twenty years ago and in 1903 a shaft was sunk. This shaft is 212 feet deep to the sump, from the bottom of which diamond drill holes were put down 300 feet farther, some vertical and some at 45 degrees. The levels were run at 100 and 200 feet. This property was worked for about two years and about 500 tons of ore were shipped on sleighs to Northland. The shaft cannot now be examined owing to water, but the ore-body is supposed to be similar in general character to the Breitung deposit.

A short distance north of the Williams mine on the eastern side of Loon lake, near Midge lake, a prospect was opened up in the spring of 1921, by Mr. E. P. Mason, who has done some stripping over an area 500 feet by 300 feet and has exposed the rock surface very well. The rock is a mixture of granite and Keewatin diabase, and the ore occurs in conjunction with quartz veins in a manner similar to the occurrences at the Williams and Breitung mines. There are two distinct sets of veins, a northwest-southeast set, and an east-west set; of these the northwest-southeast set is the more recent as all the veins are continuous at the junctions, whereas the veins in the east-west set are cut off or show signs of displacement. A drill hole has recently been put down at an angle of 40 degrees to a depth of 510 feet. It discloses almost the same rock conditions as at the surface: an alternation of Keewatin greenstone and bands of intrusive granite, with here and there quartz veins carrying an insignificant amount of specular hematite.

The occurrences of ore in all these places are very much alike and appear to be impregnations (with some replacement) in the sheared rocks of fault zone. It is very doubtful if any body of ore large enough for commercial development will ever be found in this vicinity.

The Campbell claims in the northern part of lots 6 and 7, concession VI, of Deroche, and the adjoining portion of the township of Shields were also visited. The ore here contains magnetite, but the dip needle showed very little attraction.

These claims were visited in 1910 by Mr. Sjostedt who says: "The iron occurs in a contact between the Laurentian and Huronian formations. The rocks on the west side are granite, gneiss, syenite, etc., while those on the east side are Huronian schists. The walls where visible are well defined." He also gives the iron content of the ores as varying from 38·83 per cent to 58·93 per cent.

In 1914, John A. Dresser visited the claims and wrote:[1] "The rocks seen upon the property, with the exception of certain dykes, likely all belong to the Keewatin series, hornblende schist, hornblende gneiss, and diorite may be distinguished, but exposures of fine-grained greenstones predominate. Outcrops of a coarse-grained basic syenite dyke (locally called granite) were seen along the western side of the beaver meadow near the camp. At various places on the property are to be seen outcrops of magnetite-bearing bands. These appear too siliceous to form a merchantable ore and may be better described as banded iron formation. The formation is sufficiently different in character from what is described as 'banded iron-formation' in other localities to require special description. Here neither the bands of ore nor the siliceous bands have clear-cut boundaries. Both lie in narrow, parallel streaks, the magnetite apparently blending gradually into siliceous material. The banding is made apparent chiefly by the bands of nearly white silica, and occasionally by bands of reddish garnet. On surface exposures the banding is much more conspicuous than on fresh surfaces, as the magnetite has weathered faster than the siliceous and garnetiferous bands and so is low in relief compared with them. On the series of exposures stretching northwestward from the beaver meadow the strike of the iron formation seems pretty uniform and is about north 30 degrees west; the dip is about vertical. On the other series to the northeast along the trail from Wabos the strike varies from northeast and southeast to east and west; the dip is vertical. At some of these later exposures intrusive granite dykes are exposed, which evidently have disturbed in some degree at least the previous position of the iron formation."

A consideration of the whole area only confirms the doubt that economic deposits of iron ore will be found in any of these four townships.

LEAD ORE: VICTORIA AND CASCADE MINES

These mines are outside the area under consideration, in lots 4 and 5, concession III, Jarvis township, which adjoins Deroche on the south. The mines are supposedly lead mines, but are at present shut down for lack of ore. They were opened about fifteen years ago and, about 1910, a new set of machinery was installed at the Victoria mine. Both mines are situated on Driving creek, the Victoria one-half to three-quarters of a mile below the Cascade. At the latter there are, apparently, two small veins of calcite carrying a little galena; at the former there certainly does not seem, from superficial evidence, to be sufficient ore to warrant the construction of a mill.

The object of the visit to these mines was to ascertain if Huronian rocks were in this vicinity. From Loon lake to the mines the only rocks seen were granite and diabase, the granite being pink and in every way resembling that near Northland. A large mass of coarse-grained diabase, as well as various fine-grained dykes, was found near the mines themselves.

A trip northwards from Garden River as far as the mines showed that Huronian rocks are to be found to within a short distance south of them. R. G. McConnell, whose courtesy the writer greatly appreciated, is investigating this area for the Ontario Bureau of Mines.

COPPER ORE: SUPERIOR MINE

This mine lies on the northern boundary of the township of Gaudette. After a shaft had been sunk about 400 feet operations were suspended and the shaft was allowed to fill with water. During the summer of 1921 the shaft was pumped out

[1] Information supplied through the courtesy of the Algoma Steel Corporation.

and the mine was prepared for examination with a view to purchase. There was originally a spur line from mile 39½ on the Algoma Central railway, but this has fallen into disuse and the rails have been carried away. The old bed, however, can be used as a wagon road. The railway track traverses for the most part rocks of the Pre-Huronian complex comprising dark gabbro-like rocks with inclusions of hornblende schist, mixed with granite, and the whole cut by pegmatite dykes. In the immediate vicinity of the mine there is a mass of greenstone and about 500 yards along the track is a diabase dyke about 200 feet wide. The ore, which is a mixture of pyrite and chalcopyrite, occurs associated with quartz stringers in a brecciated zone in the greenstones. No evidences of any large mass of ore were found in the vicinity.

BRICK CLAYS

Outcrops of stratified clay are abundant along the banks of Goulais river south and west of Searchmont. The most extensive and important outcrops are about one mile west of Glendale where the clay outcrops for over 1,000 feet along the river. The average exposed thickness is about 20 feet, but in one place it is 50 feet thick. In no case was the base of these clays seen. They are overlain by unstratified, or very poorly stratified, gravel and sand, probably river-worked glacial materials.

These clays are light grey, fine-grained, and highly calcareous. They are very finely laminated, due to alternation of layers of clay and sandy clay, and originated, probably, in an arm of lake Algonquin, a predecessor of lake Superior, which must have extended up the Goulais valley beyond Searchmont.

Two small samples from these deposits were submitted to the ceramic laboratory of the Mines Branch, with the following results.

"When gauged with water they develop very poor working properties, being very weak and flabby. When passed through a tile die, the test pieces deform from their own weight. Both clays will stand rapid drying.

The following are the burning tests of the wet-moulded bricklets:

Sample	Cone	Fire shrinkage	Absorption	Colour
		%	%	
6 F..	06 3	5 softens	20	Dirty buff
7 F..	06 3	5½ softens	19	Dirty buff

6 F Algoma Central Railway mileage 32½, near Searchmont.
7 F Goulais river, one mile west of Glendale.

They are both low-grade clays useful only for making common stiff mud-bricks."

WANAPITEI LAKE MAP-AREA

By T. T. Quirke

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Illustration

Map 1948. Wanapitei Lake area, Sudbury district, Ont. . . . 35

INTRODUCTION

During the season of 1921, work was carried on in the region of lake Wanapitei for two primary objects; the mapping and classification of the Precambrian sediments, and the investigation of the ore deposits. The lake level has lately been raised, artificially, 16 feet, with the result that some islands have become peninsulas, and others have entirely disappeared; and the main shoreline itself has been locally affected, especially in the northeast part of the lake, where what was once a headland is now an island half a mile from the shore. A resurvey of the lake was consequently included in the season's work.

The writer was assisted by R. C. Emmons and W. L. Swanson, both of whom rendered intelligent and loyal service.

The main results of the season's work are: a corrected geographical and geological map; additional knowledge in regard to the ore deposits; and the elimination of the type occurrence of Wanapitei quartzite from the Sudburian series and its recognition as part of the Mississagi formation of the Bruce series.

GENERAL CHARACTER OF THE AREA

Wanapitei Lake area includes Rathbun, Aylmer, Mackelcan, and parts of Parkin, Norman, Capreol, Maclennan, Scadding, Fraleck, Telfer, and McConnell townships, and the old Indian reserve. The area covers only about 40 square miles, but is in a strategic position, lying, as it does, between the area of Map 179 A, Onaping sheet, issued in 1917, by W. H. Collins, and the area of Map 124 A, Wanapitei sheet, issued in 1914, also by Collins. It includes part of the area shown on Map 125, Sudbury sheet, issued in 1891, by R. Bell, and the northeast corner of the area represented on Professor Coleman's geological map of the Sudbury nickel region issued in 1905, by the Ontario Bureau of Mines.

The work done in this area thus connects the areal mapping of Coleman and Collins, and helps to bridge the gap between the detailed mapping of the Sudbury region and the detailed mapping of the Cobalt area which have been carried on by officers of the Ontario Bureau of Mines. It falls happily into the group of type areas by means of which Collins[1] worked out thoroughly the original Huronian area, showing that the subdivision of the sediments of Huronian age into the Bruce and Cobalt series holds good not only from Echo lake to Sudbury, but eastward beyond Wanapitei lake. Historically, it connects some of the latest work on the Precambrian sediments of Canada with some of the earliest, especially that of Alexander Murray in 1856.

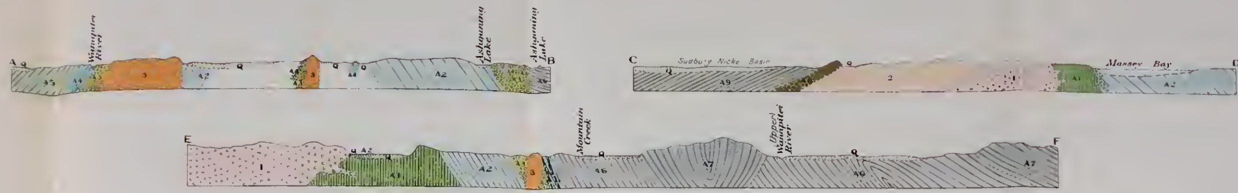
[1] Collins, W. H., Geol. Surv., Can., Mus. Bull. No. 8, 1914.

Canada
Department of Mines

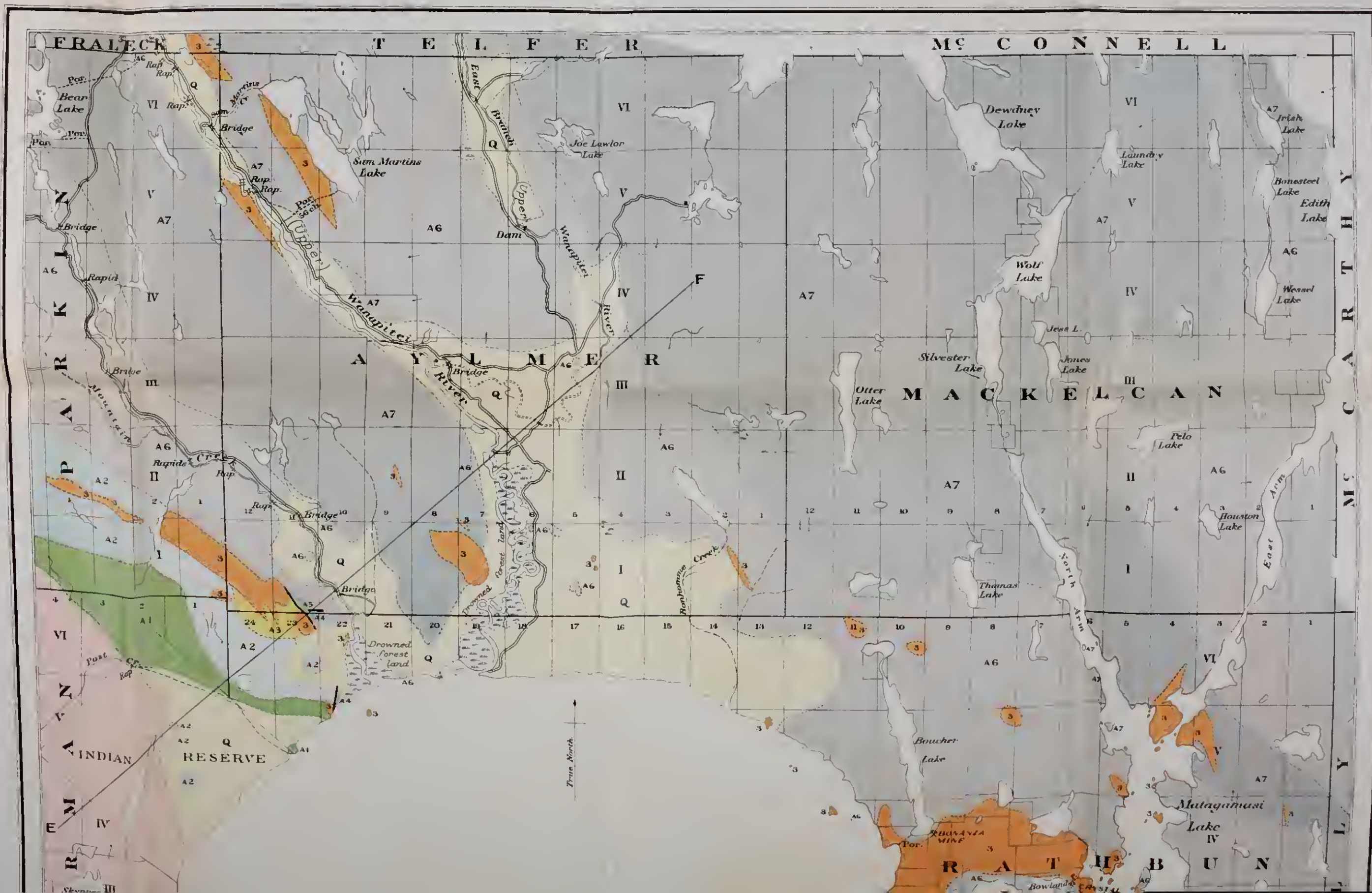
HON CHARLES STEWART MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY
W H COLLINS, DIRECTOR

Issued 1922



Structure sections along lines A B, C D, and E F.
Vertical scale exaggerated



LEGEND

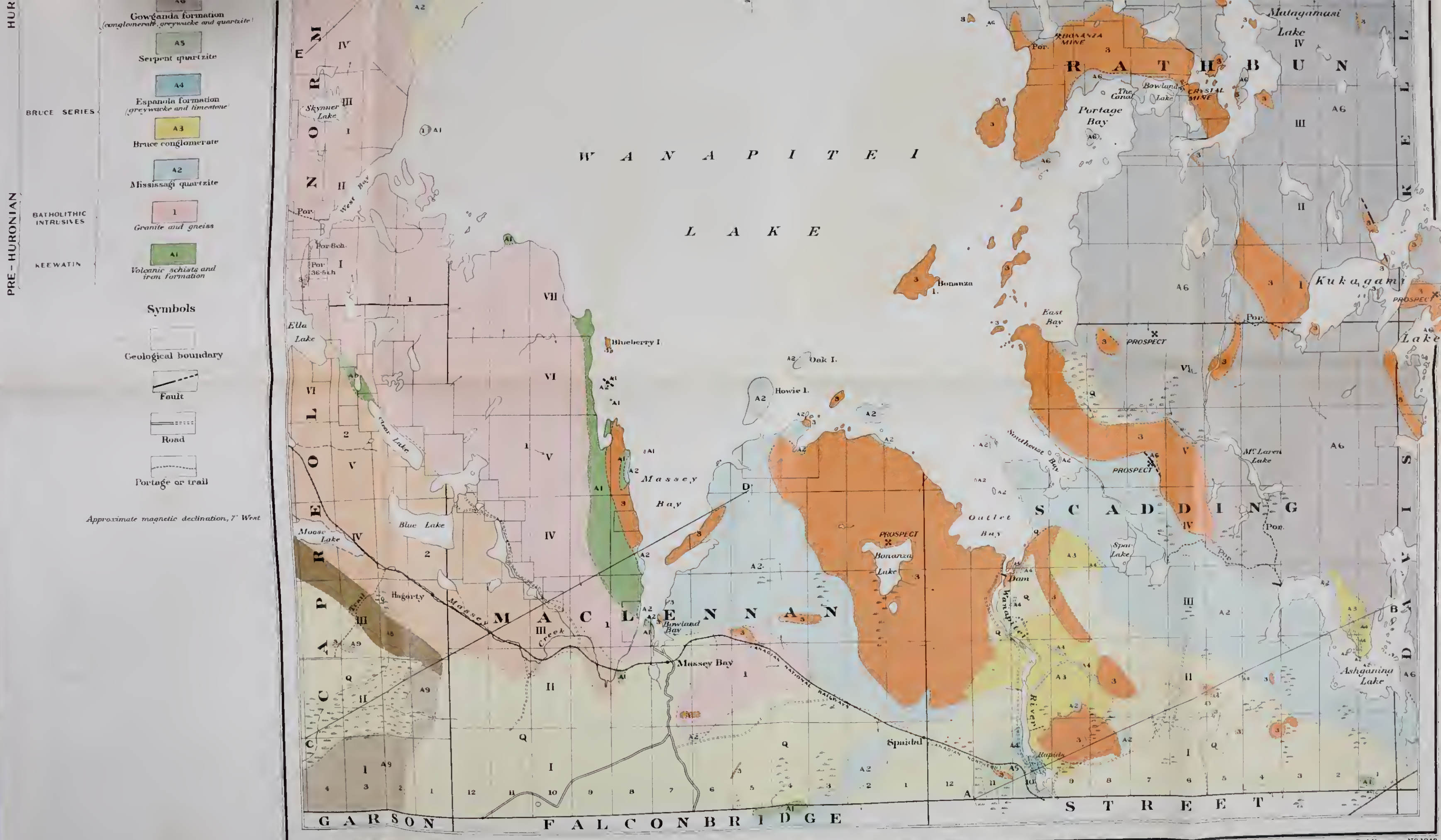
QUATERNARY
PLEISTOCENE AND RECENT
Q Sand and gravel

KEWEENAWAN(?)
3 Diabase
2 Norite

HURONIAN
WHITEWATER SERIES
A9 Onaping tuff
A8 Trout Lake conglomerate

COBALT SERIES
A7 Lorrain quartzite
A6 Gowganda formation (conglomerate, greywacke and quartzite)
A5 Serpent quartzite
A4 Espanola formation (greywacke and limestone)

BRUCE SERIES



C.O. Senécal, Geographer and Chief Draughtsman.
A. Joanes, Draughtsman.

Publication No. 1948

WANAPITEI LAKE AREA, SUDBURY DISTRICT, ONTARIO.

Scale of Miles

1 ¾ ½ ¼ 0 1 2 3 4

Sources of Information

Geology by T. T. Quirke, 1921.

Base map from surveys by T. T. Quirke, 1921; and from plans of surveys by the Department of Lands and Forests, Ontario, and the Canadian National Railways, Canadian Northern.

To accompany Report by T. T. Quirke, in Summary Report, Part D, 1921.

The area is easily accessible, being on the line of the Canadian National railway, between Capreol and North Bay. The station of Massey Bay within the area and 11 miles from Capreol, is only a few hundred feet from the top of Bowland bay on lake Wanapitei. The area is also easily entered from Crerar station, about 1½ miles from the southern end of Ashganing lake. The various canoe routes and trails are shown on the accompanying geological map (No. 1948).

There is a fairly good automobile road from Sudbury to Massey Bay. Motor boats and canoes can be hired either at Massey Bay or at the old Crystal mine between Bowland lake and Matagamishing lake.

A considerable amount of timber is still being driven down Wanapitei river and the lumbering tote roads are kept in good condition. So far as these roads and the water routes are concerned the area is fairly accessible, but off the roads travel is rendered difficult by the second growth which conceals wind falls and partly burned stumps and tree trunks, a result of the frequent fires that have laid waste the forests,[1] especially Scadding township where the most difficult geology seems to lie.

Physiographically the area is a particularly interesting example of highlands resulting from the erosion of synclines of the Huronian series of rocks, so that the highest hills are composed of the youngest formation, the peculiarly resistant Lorrain quartzite. These hills run parallel to the courses of Mountain creek and the upper Wanapitei river, coinciding for about 7 miles with a narrow tongue of quartzite which is bounded on the east and west by a less resistant slaty formation. In the southwest lies the most easterly rim of the Sudbury basin, the highest edge of which is formed by the resistant Trout Lake conglomerate.

Bedrock is well exposed to the north and east of lake Wanapitei except in the large sand-plains around the mouths of Post creek, Mountain creek, and upper Wanapitei river, and along the valley of Wanapitei river and its east branch. In the south and southwestern part of the area, the rocks are covered extensively by stratified sand and gravel which lie considerably above the present level of lake Wanapitei, and in the area southwest of Massey Bay station, show evidence of having been deposited at three different stages, about 50 feet apart in elevation. The top plain is a step above the middle one, which in turn seems to form an escarpment above the lowest. The level stretch of the highest plain is a very marked topographical feature. A thick glacial deposit extends across the area to the south of lake Wanapitei, but outside that zone the area shows abrasion and but little deposition due to glacial invasion.

GENERAL GEOLOGY

EARLIER WORK

The earliest report upon the geology about lake Wanapitei is found in the descriptions of Alexander Murray,[2] who in 1856 mapped certain water routes including Wanapitei river and lake and the large lakes between lake Wanapitei and Sturgeon river. Murray's section of the Huronian rocks found in the area follows in ascending order.

1. Fine-grained, green, siliceous slates, with the bands of green quartzite interstratified; also fine-grained slates, sometimes of a green tinge, and often bluish or black, weathering very black; occasionally some layers assume a reddish colour; copper pyrites and iron pyrites are frequently present in this division.

2. Slate conglomerate, the matrix always greenish in colour; sometimes it has a regular slaty structure, at other times it resembles a massive, fine-grained greenstone trap; it holds pebbles of white and red syenite in great profusion, with occasional masses of green, brown, and red jasper, rounded in form; associated with the conglomerate, and probably not far from the division No. 1 are green slates in very regular laminæ, cleaving with the bedding, and usually cut by parallel joints.

[1] Bell, Robert, Geol. Surv., Can., Ann. Rept., vol. IV, 1889-90, pt. F, pp. 7-8.
[2] Murray, Alexander, Geol. Surv., Can., Rept. of Prog., 1853-6, pp. 171-179.

3. A band of limestone; its strata always appear very much disturbed, and it is in general associated with greenstone. The prevailing colour of the limestone when found in mass is a pale whitish-grey, sometimes passing into dark blue; the band is frequently brecciated, and often displays rough jagged edges, which appear to belong to layers of hornstone; parts of the band are indurated calcareous shale, and these occasionally contain fine-grained siliceous pebbles.
4. Slate conglomerate resembling the slate conglomerate on the other side of the limestone.
5. Green siliceous chloritic slates, with some tolerably strong bands of quartzite.
6. White and very pale, sea-green, close-grained quartzite, with beds of quartz conglomerate interposed, and layers of talco-quartzose slate, sometimes of a dark green colour, but more frequently a pale flesh-red. The pebbles of the conglomerate are chiefly small, white, opaque, rounded masses of quartz, but these are occasionally mixed with rounded masses of red and green jasper.

It is plain that Nos. 2 and 4 are descriptions of the Gowganda formation. No. 1 may be a composite description of the Serpent formation and certain phases of the Gowganda formation, the reddish-coloured slaty rocks being rather common in the Gowganda formation of this area. No. 3 is an excellent description of the Bruce limestone. No. 5 refers to the transition phase from Gowganda formation into Lorrain quartzite, and No. 6 is unmistakably of the Lorrain quartzite. Apparently Murray did not recognize the place and identity of the Mississagi quartzite, nor how to tell apart the Gowganda and Bruce conglomerates.[1] He reported syenites intruding contorted slates on the north shore of lake Wanapitei, but the rocks are actually Keewatin volcanic schists intruded by granite. He noted further that "the whole of the west and south shore of the lake displays the effects of a very high degree of disturbance, and slates, conglomerate, quartzite and greenstone, with brecciated limestone, come in strangely irregular juxtaposition." In spite of this irregularity (which Murray did not exaggerate) and the omission of the Mississagi formation, his section is surprisingly correct, especially when the briefness of his examination is considered.

Robert Bell[2] in 1921 issued a report on Sudbury mining district; in which he included a general description of the rocks exposed along the shores of lake Wanapitei and the water routes between Portage bay and Sturgeon river. An appendix contains certain notes by Professor H. G. Williams on the microscopical character of rocks.

Professor A. P. Coleman[3] has supplied most of the detailed information about Sudbury district. To him are due the description and definition of the Sudbury series, the classification of the deposits later known as the Whitewater series, and treatise on the Sudbury norite-micropegmatite sill and the nickel-copper ore deposits. He classified the formations of the Sudbury series as follows:

	Feet
Wanapitei quartzite	20,000
McKim greywacke	7,000
Copper Cliff arkose	2,000

Of chief interest in the present connexion is the Wanapitei quartzite, to which Coleman assigns a thickness of 20,000 feet, which he says becomes distinctly metamorphic near the intrusion of granite and extends eastward to near Wanapitei river south of Wanapitei lake.

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[1] Cf. Jour. of Geol., vol. XXIX (1921), pp. 470-472.
[2] Bell, Robert, Geol. Surv., Can., Ann. Rept., vol. V, 1889-90, pt. F, pp. 14-17.

[3] Coleman, A. P., Ont. Bur. of Mines, Ann. Rept., pp. 235-303, 1903.
Ont. Bur. of Mines, Ann. Rept., pt. 1, pp. 192-224, 1904.
"The Nickel Industry," Dept. of Mines, Can., Mines Branch, Bull. 170, pp. 3-11, 1913.
"The Precambrian Rocks North of Lake Huron, with Special Reference to the Sudbury series," Ont. Bur. of Mines, Ann. Rept., vol. XXIII, pt. 1, pp. 204, 236, 1914.
"The Sudbury Series and Its Bearing on Precambrian Classification," Congrès Geol. Inter., XII Session, 1914. Compte-Rendus, pp. 337-398.
Problems of American Geology, pp. 81-161, 1915, etc.

C. R. Van Hise and C. K. Leith[1] maintained that inasmuch as the conglomerates, greywackes, and quartzites of the Sudbury region contain limestones in the Wanapitei area, immediately east of Sudbury, they are equivalent to the lower division of the original Huronian district proper. This contention has been verified in part.

W. H. Collins[2] in 1912 studied in detail an area south of lake Wanapitei, and examined less extensively other places about the lake. He reported that the Sudbury series includes a white, hard, feldspathic quartzite, thousands of feet thick, intruded by granite, and that the Cobalt series of the Huronian division is unconformable upon the Sudburian and younger than the granite. The Cobalt series is reported to consist of basal conglomerate, greywacke, and limestone 10-15 feet thick, which grades into greywacke and finally into quartzite.

STRATIGRAPHY

The Precambrian of the Wanapitei Lake area is represented by a rather wide range of rocks. On the southwestern side of the lake, between Blueberry island and Bowland bay, numerous outcrops of Keewatin schists the oldest rocks in the area—are intruded by Precambrian granites, and overlain unconformably by the Bruce and Cobalt sediments of the Huronian. The Bruce series is represented by the Mississagi quartzite, Bruce conglomerate, and the Espanola and Serpent formations; the Cobalt series by the Gowganda formation and Lorrain quartzite. This is —although not recognized in earlier reports—almost the complete succession of sediments in the classical Huronian area near Sault Ste. Marie. In the southwestern corner there is well exposed for about 8 miles the northeastern lower contact of the Sudbury norite. The upper contact of the norite, poorly exposed for several miles, lies, with the Trout Lake conglomerate, underneath the Onaping tuff, both of the Whitewater series. Here, as elsewhere in Sudbury district, the relation of the Whitewater series to the Huronian rocks is unknown.

[1] Van Hise, C. R., and Leith, C. K., "Precambrian Geology of North America," Bull. 360, p. 439, 1907.

[2] Collins, W. H., Geol. Surv., Can., Sum. Rept., pp. 189-195, 1913. "Geology of a Portion of Sudbury Map-area, South of Wanapitei Lake, Ont."

Table of Formations

Quaternary.......	Pleistocene.........	Sand, gravels, local lake clays, morainal deposits and glacio-fluviatile derivatives.
	Great unconformity	
Huronian	Keweenawan?	Granite intrusions of post-Bruce and possibly of this age. Sudbury micropegmatite-norite sill. Diabase and norite intrusions.
	Whitewater series	Chelmsford sandstone (not represented). Onwatin slate (not represented) Onaping tuff 4,000? feet Trout Lake conglomerate 500 feet Relations unknown—stratigraphic hiatus.
	Cobalt series	Lorrain quartzite 5,000? feet Gowganda formation 3,500 feet
		Erosional and minor structural unconformity.
	Bruce series	Serpent quartzite 800 feet (partly eroded) Espanola formation Greywacke 400 feet Limestone 200—600 feet [1]Bruce conglomerate 800? feet Mississagi quartzite and basal conglomerate 5,000? feet
		Great unconformity
Pre-Huronian	Batholithic intrusives	Granite
	Schist complex (Keewatin)	Volcanic schists, and jaspilyte, "banded iron formation."

PRE-HURONIAN SCHIST COMPLEX (KEEWATIN)

In Wanapitei Lake area the Keewatin schists are well-banded, and are apparently largely of fine volcanic tuff. Some of these schists may be composed in part of sedimentary material, not necessarily of direct igneous origin. On the west side of Massey bay a green greywacke or tuff, with no perceptible bedding, weathers with a pale chipped surface. Farther north along the shore a very well-bedded tuff which because of its bedding looks like a sedimentary greywacke, shows on close examination its ashy composition. This formation is cut in many places by smoky quartz veins. In the extreme southeastern corner of the area and in the neighbourhood of Crerar station, just beyond the area to the east, the stratiform character of these pre-Huronian rocks is markedly displayed. Just north of the old Indian reserve, the schists are less schistified and resemble metamorphosed lavas. They include thin formations of a banded material within which are banded siliceous ferruginous phases, the so-called jaspilyte[2] or iron formation, common to the Keewatin schists of nearly every district north of lake Huron. Miller has described this occurrence of iron formation,[3] and nothing need be added here, except that many claims for iron have been staked in Rathbun township. The most promising are located in lot 24, concession VI, but the writer saw nothing likely to be of value.

[1] Includes those formations previously mapped as Sudbury series on Map 124A.
Includes the Ramsay Lake conglomerate of Falconbridge township as mapped by A. P. Coleman.
[2] Van Hise, Bayley, and Smith, U.S. Geol. Mono. No. XXIII, p. 362.
[3] Miller, W. G., Ont Bureau of Mines, 1901, p. 177.

PRE-HURONIAN GRANITE

The granite intruding the Keewatin schists occurs along the west shore and about the islands near the west side of lake Wanapitei. It is of alaskite type, of fine, granular texture, generally free of pegmatitic varieties or other evidence of magmatic differentiation. Professor G. H. Williams[1] described some specimens from this locality as including orthoclase phenocrysts in a groundmass of oligoclase, quartz, and biotite, and subordinate amounts of magnetite, pyrite, allanite (?), and alteration products of these minerals.

BRUCE SERIES

Mississagi Formation

The contact between the base of the Huronian series and the underlying schists and granite is exposed in very few places, but opposite the diabase point in Bowland bay may be seen the unconformable contact between a basal conglomerate and an underlying body of schists which contains an intrusion of acid rock. The contact follows close to the shore for nearly 3 miles, but the relations are obscured by intrusions of diabase, and by high water. This conglomerate may well be part of the basic conglomerate of the Mississagi formation. The contact continues north to the schists near the Indian reserve, but poor exposures make it difficult to analyse. There is in some places a conglomerate close to the schists, but it is doubtful whether it is actually unconformable upon them; it may be a faulted contact, though this possibility seems unlikely. In the extreme southeastern corner of the map-area a dark conglomerate is exposed between the schist at Crerar and quartzite on the north. Among these localities there is certainly no question about the character of the contact on Bowland bay, nor is the relation in other places seriously in doubt. In general it may be said that the base of the Huronian is a dark-coloured quartzitic conglomerate.

Above the conglomerate, which is less than 50 feet thick, is a thick quartzite member which is most probably from 3,000 to 5,000 feet thick. The quartzite, very well exposed on the east side of Bowland bay, runs with diabase interruptions to Southeast bay by way of Howie and Oak islands both of which give excellent exposures, and continues to the north of the Indian reserve, composing most of the peninsula and the islands between Bowland bay and Outlet bay. It outcrops again from Outlet bay to Southeast bay, and upon Ashganing lake, and thence passes to the southeast beyond the borders of the area.

Inasmuch as the conglomerate member and the quartzite are together correlated in this report with the Mississagi formation as described by Collins,[2] whereas Coleman[3] called this quartzite the Wanapetei quartzite and placed it in the pre-Huronian, Sudbury series, it is deemed advisable to describe in detail some of the exposures of these rocks.

On the west side of Massey bay, lot VIII, concession IV, syenitic rock intrudes greenstone schists containing many smoky quartz veins, and both are overlain unconformably by a basal conglomerate, here correlated with the Mississagi formation. The syenite is greatly kaolinized, apparently by prolonged weathering. This weathering must have been previous to glacial times at least, because other glaciated feldspathic rock surfaces are not appreciably kaolinized, and apparently it represents the work of the elements previous to deposition of the basal conglomerate. The schist is much chloritized so that its original character is indistinguishable. The overlying conglomerate contains relatively few elongated pieces of schist and relatively many rounded pebbles and boulders of dark chert or smoky quartz. The basal layer of conglomerate is about 2½ feet thick, and is overlain by 6 feet of coarse

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1 Williams, G. H., Geol. Surv., Can., Ann. Rept., vol. V, app. I, 1889-90, p. 59 F.
2 Collins, W. H., Geol. Surv., Can., Mus. Bull. No. 8, 1914.
3 Coleman, A. P., Ont. Bureau of Mines, Ann. Rept., vol. XXIII, pt. 1, 1914, pp. 213-214.

arkose, followed by 7 feet of conglomerate containing many smoky quartz pebbles and cobbles and a few boulders of granite up to 8 inches in diameter. Further exposures are covered by the high water of the lake.

On the shores of the peninsula between Massey bay and Outlet bay, the Mississagi quartzite strikes in general about north 10 degrees east and dips about 12 degrees south, although there are minor rolls where the dip is reversed. The rock is crossbedded in places, but in general well-bedded every 2 or 3 feet. It weathers a pale greenish yellow, but on fresh surfaces it is pink. It is an arkose, with many clear quartz grains, some being one-tenth inch in diameter. In places there are small inclusions of mudstone, in others streaks of fine-grained, siliceous greywacke. In general it is a fairly coarse, crossbedded arkose containing rounded quartz grains and kaolinized feldspars, together with certain streaks 2 inches thick of conglomerate carrying pebbles up to 2 inches in diameter, of quartz and granite.

At the north end of Howie island the quartzite is decidedly reddish: at the south end it is pinkish, but between the pink below and the red above the quartzite is pale greenish yellow. Near the north end of Oak island is a greywacke phase showing ripple-marks, some mud-cracks, well-marked dark bedding, greywacke streaks, also small lenses of sand in the dark greywacke.

Just west of the mouth of Mountain creek the Mississagi quartzite is well bedded, varying from fine-grained, pale weathering arkose to greenish, sandy rock characteristic of the Mississagi formation. Quartz and feldspar sand alternate in places causing a characteristic appearance of lining on weathered surfaces, but the formation contains an unusual amount of recurrent conglomerate bands with highly siliceous matrix, carrying chiefly quartz pebbles up to 3 inches in diameter. The beds are slightly overturned, as is shown by the position of the overlying Bruce conglomerate and by the position and shape of the crossbedding lines. At a distance of 15 chains from the point opposite the neighbouring island is a fault line bearing south 15 degrees west, which brings the limestone formation next to the base of the Mississagi formation.

On the south side of the outlet of Ashganing lake is an outcrop of quartzite, which is correlated with the Mississagi formation, being highly vitreous and granular in texture, dark grey on fresh faces, with many reddish streaks and stains, cut by many quartz veinings. It has the general appearance of being near a younger granitic intrusive rock, although no such granite outcrops nearby. However, quartzite correlated with this formation is intruded by granite in the map-area immediately south of Wanapitei Lake area (Map 130).

Bruce Conglomerate

Overlying the Mississagi quartzite, as in the Huronian area, is a massive conglomerate, which must be the Bruce, which in this area is apparently more than 1,000 feet thick. It differs in no important way from the Bruce conglomerate along the north shore of lake Huron, where it is dark green, very siliceous in certain of its phases, rather remarkably consistent in character, and contains pebbles and a few boulders of granite and greenstone with still fewer pebbles of quartz and metamorphic rocks. No boulders of clearly sedimentary origin were discovered in the Bruce conglomerate, though more careful search might discover some.

Other parts of the North Shore region, notably Espanola, contain the Bruce conglomerate distinctly stratified and including layers of quartzite and parts without any visible stratification. This is not true apparently of the Bruce conglomerate in the Lake Wanapitei area,[1] for it shows no bedding. Certain minor features are persistent, such as the peculiar pale bluff colour of the bare, weathered faces of the rock and the peculiar way in which, under deformation, the matrix of the conglomerate

[1] Cf. Collins, W. H., Geol. Surv., Can., Sum. Rept., 1913, p. 193. The Cobalt conglomerate here referred to by Collins is really the Bruce.

pulls away from the pebbles in the direction of the greatest elongation of the rocks, thereby leaving a cavity which in some cases is filled with pyrite, in other cases with calcite, or in a few cases is empty. The siliceous character of the matrix, which contains many small fragments of quartz, is another distinction noted in other areas. This discovery of the Bruce conglomerate extends its known distribution from Sault Ste. Marie not only to Sudbury district, but beyond it in an easterly direction.

Near the railway bridge across Wanapitei river, in a railway cut, is a very siliceous conglomerate with greywacke matrix carrying angular as well as rounded pebbles and boulders of granite, schist, quartz, and apparently, quartzite. Where weathered, the surface is rough with some pebbles weathered out of the matrix (the matrix of the Gowganda conglomerates is commonly more readily weathered than the included pebbles). The matrix resembles that of the Bruce conglomerate in Espanola area, in that the competent rhyolite pebbles are loosened from their surroundings by deformation of the incompetent matrix, and the matrix is characterized by so-called grits, or little quartz grains of pin-head size, but not by the small rock particles that characterize the matrix of the Cobalt conglomerate.

About half-a-mile west of Mountain creek is clear evidence of the intermediate position of the Bruce conglomerate with respect to the underlying Mississagi quartzite and the Bruce limestone above. The diagnostic characteristics of the formation may, almost all, be seen, and a peculiar, pale salmon colour on weathered surfaces that, so far as the writer knows, appears in no other conglomerates of the Precambrian series.

Along Wanapitei river, about 2 miles below the outlet of the lake, the conglomerate is metamorphosed into a spotted schist, much as it is in the Espanola area, and about the southeastern part of lake Penage. Another good exposure of the (Bruce) conglomerate, showing its transition into the overlying limestone, may be seen on the east side of the rapids of Wanapitei river beside Portage island. Similarly its relations to the Mississagi formation below and the limestone above may be seen clearly at the southwest side of the large point in Ashganing lake.

The relations of the Bruce conglomerate in Wanapitei Lake area are different from those in the Geneva area, northwest of Sudbury,[1] where the Bruce conglomerate is lacking, and the Mississagi formation grades directly without unconformity into the Espanola formation. Apparently in spite of its great east-west distribution, the (Bruce) conglomerate was not as widely distributed as either the formation above it or the one below it, but at lake Wanapitei it is well and characteristically developed and exposed in many places.

Espanola Formation

The Espanola formation in Lake Wanapitei area consists of limestone and greywacke, or indurated silt, lying upon the Bruce conglomerate with a very thin transition member. The limestone member, corresponding to the Bruce limestone of the original Huronian area, must be at least 200 feet thick on Portage island, the first large island below the dam on Wanapitei river,[2] but seems to be not more than 100 feet thick in other disconnected, small exposures. On Portage island, the Espanola formation includes, above the limestone, several hundred feet of thin-bedded, slaty argillite and greywacke which correspond exactly in character and position with the Espanola greywacke of the Espanola area. It even contains ripple-marks and mudcracks and fine, interbedded layers of quartzite and greywacke, which could not be distinguished from specimens taken from Espanola area. However, the exposure of greywacke above the limestone is confined in this area to the small strip between the Canadian Northern railway and Wanapitei river near Portage island.[3]

[1] Geol. Surv., Can., Sum. Rept., 1920, pt. D.
[2] Cf. Murray, Alexander, op. cit., p. 296.
Bell, Robert, op. cit., p. 14 F.
Collins, W. H., Geol. Surv., Can., Sum. Rept., 1913, p. 193.
[3] Collins, W. H., Geol. Surv., Can., Sum. Rept., 1913, p. 193.

The limestone occurrences are of greater importance in correlating these sediments with the formations of the original Huronian area, as was clearly recognized by Van Hise and Leith, and especial value attaches to the discovery on the northwest shore of lake Wanapitei. Owing to this discovery the Bruce age of the associated rocks was recognized, and the distribution of the series thereby greatly extended in a direction not before suspected. A fault about half-a-mile west of Casselman's camp on Mountain creek cuts off good exposure of vertical limestone from the Gowganda conglomerate on the east, and apparently conformably upon Bruce conglomerate to the west. The limestone is faulted against the Mississagi quartzite near the lake shore about a half mile farther south (*See* page 40). At this place the faulted zone contains a jumble of conglomerate, quartzite, greywacke, limestone, and diabase. Much of the limestone appears to have recrystallized and formed veinlets and masses of white calcite.

Along Wanapitei river below the outlet of the lake numerous exposures of limestone bear out the common characteristics of the limestone elsewhere along the north shore of lake Huron. The rock weathers buff to red, and develops a rough-lined surface due to the unequal weathering of the interbedded calcareous and greywacke streaks. On fresh surfaces it is blue grey, in metamorphosed phases being marble and elsewhere highly siliceous, calcareous greywacke. The rapids at Portage island follow the strike of the limestone which is about 200 feet thick, exceptionally well-exposed and very little crumpled, relatively speaking, although in a vertical position. The gradation through about 2 feet, from Bruce conglomerate through greywacke into the limestone, can be seen; and beyond the limestone comes typical Espanola greywacke grading through the usual type of greywacke quartzite into a dark coloured, but light-weathering quartzite, which is the Serpent. This Espanola formation has mud-cracks, ripple-marks, and intraformational conglomerates made up of the dried mud shells that formed during emergence, and were covered again by rising water. Thus the relations of the limestone to the formations both above and below are clearly gradational. This highly critical, conformable succession of conglomerate, limestone, greywacke, and quartzite has not previously been reported as the Bruce series from any area east of Sudbury.

Serpent Formation

The Serpent formation has been recognized only in the small area parallel to Wanapitei river, stretching on both sides of the Canadian Northern railway for about a mile eastward from the station of Spaidal, and in a very small area in lot 2, concession I, Aylmer township. In most places along the north shore of lake Huron the Serpent formation is arkosic quartzite. A great thickness is reported from some localities, especially the area about the western end of lake Penage. The formation is characterized by an unusual development of conglomerate and grit in the Geneva map-area. It is impossible to tell how thick the Serpent formation originally was in Lake Wanapitei area because the top is nowhere recognized, and its relations to the surrounding rocks are obscured by drift in the south and by faults in the north. The formation is a dark quartzitic greywacke, characterized by streaks of ripple-marked and mud-cracked greywacke within beds of pale green quartzitic arkose. It is evidently conformable above the Espanola greywacke formation and seems to correspond pretty closely in character to the lower part of the Serpent formation in the original Huronian area.

COBALT SERIES

Gowganda Formation

Collins,[1] in his report on the Onaping area, classified all of the local sediments of Huronian age, older than the Lorrain quartzite, under the name Gowganda formation and mapped[2] the limestone and all the conglomerates as part of the Gowganda

[1] Collins, W. H., Geol. Surv., Can., Mem. 95, 1917.
[2] Map 124A, Wanapitei, Sudbury district, Geol. Surv. Can.

formation. Subsequently, however, work carried on by Collins[1] in the Precambrian of the original Huronian area led him to suspect that some of the rocks mapped on Map 124A are in part, if not altogether, of the Bruce series, as indeed this season's work has made certain. The map (No. 1948) accompanying this report restricts the Gowganda formation to those phases of the Cobalt deposits which lie below the easily recognized, characteristic Lorrain quartzite and which are unconformable upon the Bruce series; and shows the Gowganda formation is well developed.

The Gowganda, which is generally referred to as the "Cobalt conglomerate." is the formation to which Coleman[2] first ascribed a glacial, and for which W. L. Whitehead[3] has recently suggested a fluvial, origin. Whitehead's conclusion has been vigourously criticized by Coleman[4] who points out, among other things, that the well-known bedding referred to by Whitehead is due probably to standing waters and not to rivers. Whitehead seems to have ignored most of the many previous discussions of the subject that preceded his own, which was based apparently on one season's work in the Cobalt district, an area of about 6 square miles. Other workers have published the results of observations made during many seasons over areas aggregating thousands of square miles. Nevertheless, Whitehead's paper is useful because it emphasizes once[5] again that not all but only parts of the Gowganda formation appear to be of glacial origin. There are hundreds of feet in the formation where it is useless to look for a clear suggestion of glacial origin, and if Whitehead's paper was based on such parts of this formation, he would find little to support the contention that the formation is of anything but deposition from running water, being well sorted, including alternating bands of arkose, slate-like rock, and gravelly lenses, which may well have been deposited partly in running and partly in standing water. It is probably no exaggeration to say that the greater part of the Gowganda formation provides no evidence of a glacial origin, as will be clear from a study of detailed sections[6] of the formation. On the other hand, certain members of very finely laminated argillite or greywacke carry scattered pebbles and small rounded cobbles which must have been deposited by some agency other than that which deposited the matrix. The natural assumption is that this other agency was floating ice. Again, there are other bands, within the Gowganda formation, composed of unsorted bouldery conglomerate. These bands are associated with the beds of finely laminated greywacke which carry pebbles, and within such bouldery layers are striated and deangulated rock masses which in every way appear to be of the same character as those produced by recent glaciation. Thus a general study of the whole Gowganda formation gives an impression different from that gathered from most reports, and a good deal more inclusive than that given by Mr. Whitehead.

The Wanapitei area sheds little new light on the intricacies of the Gowganda formation, and descriptions from certain localities will serve as types of its different phases. A section across the nearly vertical Gowganda beds on both sides of Mountain creek reads as follows, starting about one-half mile west of Casselman's camp on the creek and going diagonally across the formation northeastward, from near the base of the formation upwards:

1. Massive, bouldery conglomerate containing boulders up to 14 inches in diameter, the matrix being slaty near the base, becoming siliceous higher up.
2. Siliceous greywacke, bedded like quartzite but containing pebble streaks.
3. Massive greywacke with very irregularly shaped granite pebbles and cobbles 8 inches in diameter.

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[1] Personal communication.
[2] Coleman, A. P., Rept. Ont. Bureau of Mines, vol. XIV, 1905, pt. 3, p. 129.
[3] Whitehead, W. L., Econ. Geol., vol. XV, 1920, p. 105.
[4] Coleman, A. P., Econ. Geol., vol. XV, 1920, pp. 539-541.
[5] Wilson, M. E., "The Cobalt Series: Its Character and Origin," Jour. Geol., vol. XXI, 1913, pp. 121-141. *See* particularly pp. 133-134 and 140.
Collins, W. H., Geol. Surv., Can., Mem. 95, 1917, pp. 80-84.
Quirke, T. T., Geol. Surv., Can., Mem. 102, 1917, pp. 43-49: Sum. Rept., 1920, p. 12 D.
[6] For detailed sections *see*
Collins, W. H., Geol. Surv., Can., Mus. Bull. No. 8, 1914
Quirke, T. T., Geol. Surv., Can., Sum. Rept., 1920, pp. 14 D-15 D.

4. Siliceous, massive greywacke, and banded greywacke with scattered pebbles.
5. Gradation into massive, siliceous greywacke.
6. Banded greywacke with streaks of quartzite up to one inch wide.
7. Massive pebbly conglomerate with matrix of dark green argillite, carrying granite pebbles and boulders up to 10 inches in diameter scattered irregularly and sparsely. The pebbles become small, few, and irregular in shape higher up the formation, the matrix weathering with a peculiar, chipped-out surface like a ripple-marked outcrop characteristic of certain phases of the Gowganda[1] formation.
8. Gradation into a finely laminated slate-like rock free of quartzitic material or pebbles, nearly vertical in position, over 200 feet wide across the strike.
9. Gradation into more massive greywacke carrying pebbles scattered irregularly through it, being less than half the Gowganda formation.

Again, at "Camp 3" in the northeastern part of the area is a typical section of the Gowganda formation lying just below the transition phase into the Lorrain quartzite. It is a coarse bouldery conglomerate with a massive greywacke matrix containing many inclusions of alaskitic granite and schist. The inclusions are of irregular shapes scattered 2 or 3 feet apart and about 8 to 10 inches in diameter—one noted was 3 feet by 2 feet. The matrix is green and argillite-like, containing many small chips and unrounded fragments of granite. This is considered to be typical tillite of the Gowganda formation.

A very well-bedded phase of the upper part of the formation is exposed along the shore of East bay, lake Wanapitei, and in the narrows that separate the west arm from the remainder of Kukagami lake. It is made up of definite, resistant beds of quartzitic greywacke, from 3 to 6 feet thick, separated by streaks of greywacke with or without pebbles. Many of these greywacke beds weather into the appearance of red slate, which is probably the rock referred to by Murray in his formation No. 1 (*See* page 35). This phase is overlain by massive conglomerate, which may be seen plainly at the south end of Matagamisi lake, along MacLaren creek, on the southern shores of Kukagami lake, and near "Camp 3," as noted above. The well-bedded phase recurs near the top of the formation, being especially prominent where the strike of the rock bears nearly parallel to the upper course of the East branch, giving rise to a succession of cliff-fronted hogbacks facing westward.

The Gowganda formation of Lake Wanapitei area, therefore, consists in general from the base upward of the following phases:

1. A roughly stratified basal conglomerate member.
2. A very well-bedded, thinly laminated argillite, which grades upward into well-bedded, quartzitic and red slaty greywacke and pebbly conglomerate.
3. By the addition of boulders and cobbles and by the loss of definite bedding, this becomes a massive greywacke, bouldery conglomerate.
4. A repetition of the quartzitic and greywacke well-bedded phase, which grades finally into the Lorrain quartzite.

Lorrain Quartzite

Immediately above the Gowganda formation, after a gradation of several scores of feet, the dark greywacke of the Gowganda formation gives place to a singularly pure, pale green quartzite, which outcrops in tongues in the northern part of the area, one stretching from the southeast corner of Fraleck township to the mouth of upper Wanapitei river, and the other extending from a point about one-half mile east of the East branch, westward almost to the northeast corner of the area and southeastward to the northern division of lake Kukagami. This quartzite constitutes the range of high hills—clearly visible from Massey Bay—to the north of lake Wanapitei. The northern tongue being a sharply folded syncline is now a precipitous hill; the northeastern tongue is a much more gently-folded syncline not nearly so lofty nor so rugged as the northwestern, which is bounded on nearly every side by precipitous breaks that make it very simple to map. The lines of contact together with the direction of strike, in general, are persistent over considerable distances, whereas in the northeastern tongue unequal erosion of the surface has resulted in an irregular line of contact all the more pronounced on account of the relatively low dip of the formation. The quartzite is characterized by streaks of small quartz and jasper

[1] Geol. Surv., Can., Sum. Rept., 1920, p. 14 D.

pebbles which seem to recur throughout the whole formation everywhere from the neighbourhood of Sault Ste. Marie to the Cobalt district, where it was first called Lorrain arkose.[1] Inasmuch as it is the youngest known formation of the Huronian series, it is found solely in the synclines where it is commonly metamorphosed into a green mica schist of aged appearance.

Collins[2] reports the lack of jasper pebbles in the Wanapitei area, but they were found this season although they are scarcer than in most Lorrain localities. He reports the presence of an overlying cherty quartzite which was not recognized by the members of this party.

Nature of the Bruce-Cobalt Contact

Nowhere in Wanapitei Lake area, except possibly on lake Ashganing, was a good exposure of the contact at the base of the Cobalt series with the underlying rocks discovered. In the northwestern part of the area the Cobalt series rocks are separated from the Bruce formations by a zone of faulting and diabase intrusions, and between lakes Wanapitei and Ashganing the contact continues. However, on the east side of the great peninsula of lake Ashganing there is an erosional unconformity which is certainly beneath most if not all of the Gowganda formation, and apparently above what is either a quartzitic streak in the Bruce conglomerate or the Mississagi quartzite. Upon the peninsula west of this contact there are two synclines containing the Espanola limestone, on both sides of which the Bruce conglomerate is repeated, but there is neither Serpent quartzite, nor any but a very little of the Espanola greywacke preserved above the limestone. Apparently the Bruce series was folded into a small synclinorium at this place during the pre-Cobalt period of erosion and previous to the deposition of the Gowganda formation. The unconformable character of the contact is indicated by the existence of a considerable thickness of the Serpent formation between Wanapitei river and Spaidal station, whereas the Serpent formation was found nowhere else under the Cobalt series except for a few hundred square feet west of Casselman's camp, as before noted. In these latter places the Serpent formation must have been eroded before the deposition of the Gowganda formation.

There are certain other indications that there may have been folding movements between Bruce and Cobalt times. For instance, there seems to be a marked contrast in the degree of folding of the formations of the two series in the southeastern part of the area; the Cobalt formations dip generally less than 45 degrees, whereas the Bruce formations are nearly vertical. However, in the northwestern part of the area there is not such an obvious contrast in this respect. This is, perhaps, due to the fact that the locus of post-Huronian mountain-building lay towards the southwest.[3] Certain it is that the Cobalt series is more nearly flat-lying in the northeastern part of the area than farther south and west.

Along the north shore of lake Huron there is a profound erosional unconformity between these two series of the Huronian division.[4] Previous to the deposition of the Cobalt formation thousands of feet of the Bruce series were eroded over large areas west of Sudbury, leaving a region having considerable relief, possibly a deeply dissected plateau area. This appears to have been induced by epirogenic movements and not by orogenic disturbances, for no discordance in excess of 10 degrees has been noted between the Cobalt series and the Bruce series west of Sudbury. It is well known, however, that most periods of earth movement have included simultaneously epirogenic movements of large areas and orogenic uplift of relatively small areas. Is this not

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[1] Miller, W. G., Fourteenth Ann. Rept., Ont. Bureau of Mines, pt. II, 1905.
[2] Collins, W. H., Geol. Surv., Can., Mus. Bull. No. 8, 1914, p. 22.
[3] Geol. Surv., Can., Mus. Bull., No. 22.
[4] Collins, W. H., Geol. Surv., Can., Mus. Bull. No. 8, p. 25, 1914.
Quirke, T. T., Jour. Geol., vol. XXIX, 1921, pp. 470-471.

likely to have been the case at the end of the Bruce epoch and may not the locus of the more intense earth movements include Wanapitei area? This view is perhaps supported by the fact that the sedimentary formations south of lake Wanapitei are intruded by granite.[1] These sediments were at first taken to be pre-Huronian or Sudburian in age, but it is now certain that they are of Bruce age.[2] Nothing further was learned last summer regarding the age of these post-Bruce acid intrusions. Although the Cobalt formations of the area are not intruded by granite, it was not ascertained that they overlie the acid intrusives unconformably; consequently the evidence is in no way conclusive. In the Killarney[3] area the intrusions are known to penetrate the Cobalt series, and in the Geneva[4] area syenitic granite appears to penetrate Cobalt as well as Bruce formations.

In general we do not know that there was a period of mountain-building accompanied by igneous intrusion after the deposition of the Bruce series, followed or accompanied by a long period of erosion, previous to the deposition of the Cobalt series, and the writer feels impelled to state this as a working hypothesis which has developed as one of the results of this season's work. In any case it is certain that a period of uplift and long erosion intervened between the deposition of the youngest known formation of the Bruce series and the accumulation of the Cobalt deposits.

WHITEWATER SERIES

The formations of the Whitewater series lie in the extreme southwest corner of the area, and are largely covered with sand and gravel. The Trout Lake conglomerate at the base of the series is a remarkable formation quite unlike any of the Huronian conglomerates. It is very siliceous and is composed largely of small pebbles and irregularly shaped fragments of quartzite, chert, quartz, granite, and greywacke. No boulders more than 10 inches in diameter were seen, and the only observed individual of that size was a very irregularly shaped piece of quartzite. The formation is a rubbly conglomerate, composed of rocks of many kinds and shapes, and nearly all less than one-half inch in diameter. There seems to be little variation in its character from top to bottom, except perhaps that the upper part is better sorted. At the base, especially, it appears to be massive; no bedding planes or distinct lens or layers of gravel or greywacke were seen. The structural position of the formation is assumed from the distribution of its outcrops. It forms a long, almost straight hogback facing northeastward, and constitutes in a very striking manner part of the edge of the Sudbury basin. Within this ridge to the southwest lies a sand-plain, in which are certain outcrops of well-bedded, grey volcanic tuff which has been called by Coleman the Onaping tuff. Little can be added to previous description of these formations.[5] Neither the Onwatin slate nor the Chelmsford sandstone outcrops within the Lake Wanapitei area. The Whitewater series slopes gently towards the interior of the basin, and is separated from the Huronian formations by a band of norite, which constitutes the basin, as well as by older granites, and glacial deposits.

KEWEENAWAN INTRUSIVES

Most important of the later irruptives is the Sudbury norite and micropegmatite, just referred to, which stretches from Ella lake to the sand-plains in the south. Under the sand deposits its distribution could not be traced, but doubtless it persists. This formation intrudes the Whitewater series and seems to lie upon the pre-Huronian granite and green schists. At its northern contact numerous prospects and developments show the concentration of pyrrhotite in considerable amount in

[1] *See* page 36.
[2] Collins, W. H., personal communication.
[3] Collins, W. H., Geol. Surv., Can., Mus. Bull. No. 22, 1916.
[4] Quirke, T. T., Geol. Surv., Can. Sum. Rept., 1920, pp. 16-17 D.
[5] Coleman, A. P., "Problems of American Geology" (1915), pp. 141-144.

certain places. Diamond drilling has been carried on elsewhere along the outer edge of the norite, and exploration in general seems to have been thorough.

The contacts of other types of diabase, which are distributed in large masses from the northwest to the southeast of the area, have not been as well examined, although there are several prospects about the shores of lake Wanapitei and a few claims that have been worked for gold. The most important of these, probably, are the Bonanza on lake Bonanza, and the Crystal between Bowland lake and lake Matagamisi. There are, in addition to these, which were not financially successful, certain claims worth consideration. Visible gold occurs in many locations on the east shore of lake Kukagami; near Massey Bay; to the east of the southeast bay of lake Wanapitei; and doubtless in other places. The gold occurs in quartz veins in association with iron pyrite in some cases and in other cases with the addition of galena and carbonate. So far as known all the veins are near the contact of the diabase, and—in one promising locality at least—in the neighbourhood of a major fault which is near the contact of the diabase.

PLEISTOCENE FORMATIONS

There are considerable deposits of glacial origin in the southern part of the area, and wide sand-plains in the valley of the upper Wanapitei river and along the East branch, extending for several miles along the north shore of the lake, where they seem at first glance to represent deposits formed when the lake level was much higher than it is today. But this apparently flat sand-plain is a good deal lower near the old Indian reserve than it is along the valley of upper Wanapitei river, where the sand bluffs rise between 20 and 30 feet above the present river level. And the fact that the sand-plain is characterized by numerous ridges and other minor irregularities shows that something besides deposition on a lake bottom occasioned the accumulation of sand. The gradual rise from south to north indicates that a stream from the north deposited sand in a basin partly filled by the waters of lake Wanapitei. If the present level of the lake were raised, the water would escape through Portage bay and Bowland lake and through lake Matagamisi to Sturgeon river, hence, theories based on the assumption that the ancient lake level was much higher than at present are not very convincing. Various depressions of the kettle-hole type near Higgins bay are clearly deposits of an ice-sheet. Some of these kettle-holes are only slightly above the present lake-level, and would certainly have been buried beneath lacustrine deposits if the level of the lake had been high enough to cause the deposition of the northern sand-plain. It seems, therefore, that lake Wanapitei has never been much higher than now, and, as already mentioned, the present level has been raised artificially 16 feet. The rather curious high sand and gravel plateaus south of Massey Bay terminate abruptly in the manner of an embankment or an artificial fill, and probably represent levels of sub-glacial deposition. Their erratic distribution and varying heights seem incompatible with any theory of origin dependent upon change of widespreading water-levels. Standing waters undoubtedly played their part, as is evidenced by the stratified lake clays containing boulders near the railway bridge across Wanapitei river;[1] and although such lakes are commonly associated with the edge of ice-sheets, this does not negative the idea that the widespread, sorted, sandy material is of sub-glacial origin.

CORRELATION

Ramsay Lake Conglomerate

There are two areas of massive conglomerate, one at Ramsay lake near Sudbury, and one in Falconbridge township, which have been mapped under the local name of Ramsay Lake[2] conglomerate because the correlation of these formations was in doubt.

[1] Collins, W. H., Geol. Surv., Can., Sum. Rept., 1913, p. 195.

[2] Coleman, A. P., "The Nickel Industry," Ont. Bureau of Mines, Rept. of Mines, Can. Mines Branch, Bull. 170, pp. 6 and 8, 1913, and map of Sudbury Nickel region, Ont., 1905.

Coleman[1] thought that both these areas were representatives of the Cobalt conglomerate, and, at one time, Collins[2] agreed with him at least as far as the area in Falconbridge is concerned. This was also the opinion of Miller and Knight,[3] although they correlated both Cobalt and Ramsay Lake conglomerate with the Whitewater series under the name Animikean.

The writer visited the Falconbridge area, which lies a few miles south of the Lake Wanapitei area and is shown on Collins' Map 124A, and was able to identify the following part of the Bruce succession west of the gold claims alongside the diabase in lot 6, concession II: Bruce conglomerate, Bruce limestone, Espanola greywacke, Espanola limestone, a fault zone followed by Mississagi quartzite. In lot 5, concession III, the Mississagi quartzite underlies Bruce conglomerate, which is continuous with that in contact with the limestone. These outcrops represent an eroded series of folds wherein the structural position of the massive Bruce conglomerate is made clear by the position of the overlying limestone and underlying quartzite. The conglomerate—as both Collins and Coleman note—is massive and generally without indigenous indications of its position, and both considered it to be unconformable upon the almost vertical quartzite and limestone. However, later work has shown conclusively that the Bruce succession is quartzite, conglomerate, limestone, and it may be recognized by this order of outcropping. Furthermore, there are so many distinctive types of deposit peculiar to the Cobalt formation which are never found in the Bruce conglomerate that they can generally be distinguished on lithologic evidence alone.[4] The writer is convinced that the Ramsay Lake conglomerate of Falconbridge township is the representative of the Bruce conglomerate of the original Huronian area.

Collins[5] has identified the Ramsay Lake conglomerate of Ramsay lake as the equivalent of the quartzitic basal conglomerate of the Mississagi formation. The local name Ramsay Lake conglomerate, having served its purpose, may now, therefore, be abandoned.

Sudbury Series

Part of the formations correlated with the Bruce series in this report have previously been mapped and described by Coleman and Collins[6] as part of the Sudbury series, of pre-Huronian age. It is advisable, therefore, to explain the basis of this revision. It is only fair to begin by pointing out that the work of Coleman and Collins here referred to was done before Collins began in 1914 his exhaustive study of the original Huronian formation along the north shore of lake Huron. These studies have given us a knowledge of the true order of succession of the Precambrian formations, familiarity with the formations as geologic units, a recognition of the changing phases of certain formations, and, in certain cases, the means of diagnosing these phases by lithologic and minor structural criteria[7]. These means of correlation have been applied in any other areas since 1914 to the great simplification of geologic problems bearing upon the stratigraphy of the Sudbury and Lake Huron areas.

Although Coleman observed in 1905 that the granite at the Murray mine, near Sudbury, was intrusive in the norite, it was not generally recognized that any of the granites in northeastern Ontario intruded the Huronian sediments until the publication of Collins' bulletin on the age of the Killarney granite. Hence when sedi-

[1] Coleman, A. P., Idem, p. 9. Compte-Rendus, Congrès Géologique International, 12ième Session, Canada, 1914, p. 389.

[2] Collins, W. H., Congrès Géologique International, 12ième Session, Canada, 1914, Compte-Rendus, p. 404. Wanapitei Sheet, Map No. 124A, Geol. Surv., Can.

[3] Miller, W. G., and Knight, C. W., Jour. Geol., vol. XXIII, pp. 589 and 594, 1915.

[4] Jour. Geol., vol. XXIX, 1920. pp. 470-472.

[5] Collins, W. H., personal communication.

[6] Coleman, A. P., Ann. Rept., Ont. Bureau of Mines, vol. XXIII, pt. 1, pp. 213-214, 1914. "Problems of American Geology," p. 97, 1915.
Collins, W. H., Geol. Surv., Can., Sum. Rept., 1913, pp. 190-191.

[7] Collins, W. H., Geol. Surv., Can., Mus. Bulls. Nos. 8 and 22.
Quirke, T. T., Jour. of Geol. vol. XXIX, 1920, pp. 470-471.

mentary formations were found much folded and invaded by granite they were commonly referred to the pre-Huronian division. Coleman found at Sudbury a succession of arkose, greywacke, and quartzite, all highly folded and metamorphosed. These he included, under the names Copper Cliff arkose, McKim greywacke, and Wanapitei quartzite, in the Sudbury series, regarding them as of pre-Huronian age and separated from the Huronian (Cobalt series) by a great interval of mountain-building and peneplanation.

In the Lake Wanapitei area only the Wanapitei quartzite is present; but it is so associated with other formations of the Bruce series as to indicate it to be the Mississagi quartzite. The order of the formations mapped is the same as that in the Bruce series of the original Huronian area with the possible exception of the Espanola limestone, as follows:

Feldspathic impure quartzite (Serpent quartzite).
Stratified silty greywacke (Espanola greywacke).
Siliceous limestone (Bruce limestone)
Massive conglomerate (Bruce conglomerate).
Faint unconformity
Feldspathic quartzite, arkosic and conglomeratic at base (Mississagi quartzite or Wanapitei quartzite).

The character of these formations in the area and their succession identify them with the Bruce series. The identity of the Wanapitei quartzite with the Mississagi, has further been established by Collins, who in 1917,[1] traced the Mississagi quartzite continuously from Espanola to lake Wanapitei and found it to correspond to the Wanapitei quartzite of Coleman.

The McKim greywacke and Copper Cliff arkose formations of the Sudbury series do not occur in the Wanapitei map-area, but in Sudbury district Collins has found some evidence of unconformity between the Mississagi (or Wanapitei) quartzite and the McKim greywacke beneath it. The basal member of the Mississagi (or Wanapitei) quartzite is a thick bouldery conglomerate (the Ramsay Lake conglomerate, of Coleman) which carries a few pebbles of a sheared greywacke apparently derived from the McKim formation. The exact contact between this basal conglomerate and the McKim greywacke was found in only two places and does not throw much additional light upon the nature and importance of the unconformity.

ECONOMIC GEOLOGY

ORE DEPOSITS

Nickel and Copper

The deposits of nickeliferous pyrrhotite underlying the eastern end of the Sudbury norite which extends into the Wanapitei area have been so fully treated by Coleman that it would be wasted effort to discuss them further, except to mention that none of the properties within the map-area is now being worked.

Gold and Iron

In addition to the claims for nickel and copper, there are many claims for iron and gold. The iron ore deposits which lie in the northwestern corner of the map-area have been described by Miller[2] and need no further mention, except the repetition that they are probably of no value.

The prospects for gold deserve more extended consideration. Several claims have developed into mines, but none has been financially successful. In most cases the gold is there in specks, wires, or pieces of considerable size, but the deposits were

[1] Unpublished information about to appear upon a general geological map of northeastern Ontario, Geol. Surv., Can., No. 155A.

[2] Miller, W. G., Ont. Bureau of Mines, 1901, p. 177.

too patchy or otherwise too limited to bear the expense of mining and milling. All the mines are now abandoned. However, prospecting continues with some expectation of the discovery of profitable gold deposits.

The best known mine is the Crystal mine, which lies between Bowland and Matagamisi lakes. The main shaft is sunk in the crest of a hill of greywacke; the mill timbers and the wreck of some machinery are at the base on the shore of lake Bowland. The ore-body is a quartz vein which lies between diabase on the east and greywacke (Gowganda formation) on the west. The vein minerals are quartz, pyrite, and a carbonate, probably breunnerite (carbonate of iron and magnesium) judging from its tan-coloured weathering. The gold is free milling. Collins[1] has reported that the gold ore deposits of this district differ from the usual type in northern Ontario, and he described the Crystal mine and the geological relations of its deposits.

In many other places on the east side of lake Wanapitei, at or near the contacts of diabase and partly in the Huronian rocks, there are quartz veins which carry visible gold. The gold is free, and much of it is wire gold, which suggests that it is derived from sulphides during weathering. The gold has not been found in the country rock, outside the veins, which makes it unlikely that disseminated deposits will be found at least in the more siliceous types of rock. The commonest association of vein minerals is quartz, pyrite, galena, and gold. In the Crystal mine, and in a prospect along a great fault line between lakes Wanapitei and Ashganing, the minerals are quartz, pyrite, carbonate, and gold.

A good deal of prospecting for gold has been done in the northwest part of the area in the Keewatin formation, where the banded iron formation occurs. A prevalent idea among many prospectors seems to urge them to prospect for gold wherever there are jaspilyte beds in the schists. They believe that the iron has a precipitating effect upon gold solutions. Authenticated instances of gold-bearing quartz veins being associated with so-called "banded iron formation" are, however, more easily explained as follows: the Keewatin schists are older than many igneous intrusions which might have been responsible for episode after episode of mineralization, and the Keewatin schists contain numerous streaks of siliceous iron deposits, known as jaspilyte; consequently some of the gold-bearing quartz veins in the Keewatin rocks happened to intersect the banded jaspilyte. It is very doubtful, however, if jaspilyte itself is a good indication of gold-bearing quartz veins.

A much better guide for the prospector in the Lake Wanapitei area is the contact of diabase and Huronian sediments. As Collins observed, the gold deposits are in every case closely connected with a diabase intrusion. To this it may be added that gold-bearing quartz veins have been found along the line of major faults near diabase intrusions, the faults being younger than the intrusions. These quartz veins, however, are patchy and their content of gold irregular.

In the further prospecting for gold all major fault lines passing close to diabase intrusions should be examined carefully, especially the fault slightly west of the mouth of Mountain creek; the fault between lakes Wanapitei and Ashganing; and the fault line with a northwest-southeast bearing about one mile east of the outlet dam on lake Wanapitei. Along this last fault is a remarkable replacement of Mississagi quartzite by large feldspar crystals, apparently adularia. Such a replacement is thought to indicate the intrusion of hot aqueous solutions. Limestone outcrops should also be followed to their contact with diabase; such places may be found west of Mountain creek, and in Scadding township, according to the map (No. 1948) which accompanies this report. In Scadding the soil is so thick that none of the limestone outcrops could be followed very far; however, certain contacts of limestone and diabase are mapped, and it is recommended that these should be explored thoroughly, in the search not only for mineral veins but for disseminated deposits of gold-bearing pyrite.

[1] Collins, W. H., Geol. Surv., Can., Mem. 95, 1917, pp. 114-115.

RADIUM-BEARING PEGMATITES OF ONTARIO

By H. V. Ellsworth

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INTRODUCTION

Radium-bearing minerals were discovered near Parry Sound in February, 1921, and in August the writer was detailed to examine these prospects and to visit any other localities in Ontario where such minerals have been found or might possibly occur. As the radium-bearing minerals so far discovered in Ontario occur in pegmatite, the work resolved itself into an examination of pegmatites in general, particularly those which have been opened up for the mining of feldspar or white mica. Nearly all the feldspar or white mica mines in Ontario of which records were obtainable, besides numerous radium mineral prospects, were visited, but the time available for examination was in many cases brief. The main object of the investigation was to estimate the possibility of a commercial production of uranium-radium ore from these deposits; a secondary object was the collection of data that might prove useful to prospectors for radium minerals in other areas. Further, the analysis of uranium minerals provides a means of estimating the actual age in years of the rocks in which they occur; a point of much more practical importance than appears at first sight. There has been, and is, great divergence of opinion among Precambrian geologists as to the correlation of the widespread irruptive invasions known as the Laurentian, Algoman, Killarney, and other granites. The relationship of the Grenville-Hastings areas of Quebec and eastern Ontario to the Keewatin and Huronian of western Ontario has never been satisfactorily settled. If it were possible to obtain uranium minerals from these various granites their respective ages could be calculated, and correlation problems that have hitherto defied all other methods of attack could be solved. Apart, therefore, from the purely commercial possibilities of radium production the finding of uranium minerals may be of great practical importance in helping to solve some of the most difficult problems of Precambrian geology in Ontario and Quebec.

As a result of this investigation radioactive minerals have been found in small amounts in the majority of the workings visited, extending from Parry Sound eastward nearly to Kingston. It thus appears that uranium and thorium minerals are of quite common occurrence and widely distributed in the Precambrian rocks of this part of Ontario, though usually present only in very small quantities.

Before proceeding to the description of the various prospects, it may be worth while to say something about radium, its uses and the present situation with regard

to its production. For the data included in this part the writer has drawn on the well-known publications of Rutherford, Boltwood, Ramsay, Soddy, the U.S. Bureau of Mines, and others. Those interested in the subject of radioactivity will find the scientific side extremely well presented in Rutherford's "Radioactive Substances and Their Radiations," and the practical aspects of radium production, occurrence of ores, etc., are equally well covered by the U.S. Bureau of Mines Bulletins 70, 103, and 104.

RADIUM AND ITS PROPERTIES

Radium is a white metal resembling barium in general chemical properties. The metal has been produced only in small quantities for experimental purposes. In commercial refining processes it is obtained in the form of a compound with chlorine or bromine, hence the term radium as popularly used refers to radium chloride or bromide. In this form when freshly prepared it resembles common table salt in appearance.

Radium by itself or in compounds, possesses the remarkable property of spontaneously changing into the gas helium and the metal lead. What is perhaps just as remarkable, it does so at a fixed rate which is entirely unaffected by any alteration in temperature and pressure which it has been possible to apply up to the present. This rate is such that half of the radium is changed in 1,690 years. In the next 1,690 years half of the remainder, or one-quarter of the original quantity disappears, and so on. The transformation is not a simple, direct process, however, but takes place in stages, a number of substances of decreasing atomic weight being formed, which are really short-lived chemical elements, each breaking down to form the next in succession until the final result is a quantity of lead and helium equal in combined weight to the radium which has decomposed.

One of these intermediate substances commonly called radium emanation is of great practical importance. It is a gas, the heaviest known, having according to Rutherford one hundred and eleven times the density of hydrogen. In the treatment of cancer in institutions where comparatively large quantities of radium are available the radium chloride is kept in solution and the emanation as it accumulates is boiled off and compressed into hollow needles or other devices convenient for application. In this way greater economy and safety in the use of radium is obtained than if the radium salt itself is used. The emanation loses its potency in a short time, having a half-life period of only 3·35 days.

The disintegration of radium is accompanied by the release of a relatively enormous amount of energy. Radium produces more than enough heat to melt its own weight of ice every hour, and three types of radiations are given off called the alpha, beta, and gamma rays. The alpha rays consist of atoms of helium carrying positive electricity and travelling at a rate of about 12,000 miles a second or about one-fifteenth the velocity of light. The beta rays are extremely minute negatively charged bodies having a velocity of from 100,000 to 186,000 miles a second, or about the velocity of light, and their mass is estimated at only one sixteen-hundredth of that of the hydrogen atom. They are thought to represent the smallest unit having a part in the constitution of matter. The gamma rays unlike the alpha and beta rays are imponderable, being ether vibrations of very short wave length, like X-rays. All these radiations will affect a photographic plate and will discharge an electroscope, though in different degrees. The alpha rays are most effective in discharging an electroscope but have very little power of penetration, being stopped by a thin sheet of paper. The beta rays have about one hundred times the penetrating power of the X-rays, and the gamma rays will penetrate a foot of iron.

A substance which gives off one or more of these types of radiations is said to be radioactive.

Radium itself is formed as a result of a similar spontaneous disintegration of uranium, which, however, takes place much more slowly than in the case of radium,

the time required for the disappearance of one-half of any amount of uranium being about 5,000,000,000 years. In a ton of uranium element only about one-eighth of a milligram disintegrates annually. Thus geologically old uranium minerals furnish the only commercial source of radium, since a very long time is required for the accumulation of appreciable quantities.

A gram of uranium with its various distintegration products produces $1 \cdot 88 \times 10^{-11}$g. of helium and $1 \cdot 21 \times 10^{-10}$g. of lead per year. Hence if the percentages of uranium and of lead or helium in a mineral are known, the age of the mineral in years can be determined, assuming (1) that no lead or helium was originally present in the mineral at the time of its formation and (2) that the rate of transformation in the past has been the same as that observed at the present time. There is good evidence both experimental and geological to justify these assumptions, and geological age determinations according to this method are regarded as the most accurate and reliable that can possibly be obtained in our present state of knowledge. If we suppose a uranium mineral to be free of radium at the time of its formation, during millions of succeeding years radium is slowly produced and gradually accumulates, though it is at the same time changing to helium and lead. Eventually equilibrium between formation and decay is established; after a period estimated at from 1,000,000 to 10,000,000 years, all uranium minerals which have not suffered alteration should contain the equilibrium amount of radium corresponding to their uranium content. Numerous investigators have determined this constant with quite concordant results. The most recent determination of Lind and Roberts agrees exactly with an earlier one of Rutherford and Boltwood. This ratio is stated as follows:

1 gram of uranium is in radioactive equilibrium with $3 \cdot 4 \times 70^{-7}$ grams of radium.

In practical units 1 milligram of radium is contained in about 7·66 pounds of uranium oxide (U_3O_8) in unaltered old uranium minerals. Or if the ratio is placed at 1 milligram in 8 pounds of U_3O_8 we have a figure representing a safe working basis for commercial calculations. It follows from this relationship that the quantity of radium present in an unaltered ore can be calculated from the percentage of U_3O_8 as shown by chemical analysis.

Thorium is an element having radioactive properties similar to uranium, and like it changes into helium and lead through a series of intermediate substances. The disintegration of thorium is about three times slower than that of uranium. Thorium produces a highly active product, mesothorium, resembling radium in its properties and inseparable from it by chemical means. All thorium minerals contain some uranium and most uranium minerals carry some thorium. Hence all mesothorium preparations contain some radium and radium may contain mesothorium. The radium produced from United States carnotite, however, appears to be almost free from mesothorium.

USES

Popular interest in radium has been greatly stimulated in recent years by the increasing use of this rare element in the treatment of cancer and related malignant growths. As to the favourable influence of radium in cancer treatment there appears to be no longer any doubt. Institutions such as the General Memorial Hospital, New York, the Howard A. Kelly Hospital, Baltimore, and the New York State Cancer Hospital at Buffalo, which have had relatively large quantities of radium in use for a number of years report most favourably as to its beneficial action, though it is not effective in all cases. Its therapeutic use is being continually extended and includes many other diseases. It is worth noting that it is the very penetrating radiations or so-called gamma rays of radium or radium emanation, which are used in the treatment of cancer. The gamma rays are analogous to X-rays and it is not impossible that improvements in apparatus for production and control of X-rays may in future tend to lesson the demand for radium for this purpose. Radium has at present the advantage of much greater ease of application and control.

Water containing radium or radium emanation is supposed to have valuable medicinal properties and is taken both internally and in the form of baths. The curative value of many of the famous mineral springs of Europe and particularly the spring at Bath, England, is now ascribed largely to the presence of dissolved radium or radium emanation. At Joachimsthal in Czecho-Slovakia, water from the pitchblende mines is utilized in this way. This is worthy of note, as highly active springs may be found in the neighbourhood of the radium-bearing mineral occurrences in Ontario and such springs would, if properly exploited, undoubtedly prove a strong additional attraction for tourists and visitors to that already famous vacation land, the "Highlands" of Ontario.

The other chief commercial use of radium is in the making of the familiar luminous paint used on watches, compasses, etc. Here radium has a competitor, mesothorium, a by-product of the thorium gas mantle industry, which is cheaper and serves well while it lasts, though its effective life is short—only five to six years. On the other hand genuine radium paint preserves its luminosity indefinitely.

Experiments have been made which indicate that radium increases the growth and yield of plants, so that tailings and residues from the treatment of radium ore may have some commercial value as a fertilizer because of the small amount of unrecovered radium they contain in addition to other elements present. A company has been formed recently in Czecho-Slovakia to exploit radioactive fertilizers. Should the pegmatites ever be worked for their radium content the tailings and residues if finely ground should also be of value for their potash content, which would slowly become avaliable when applied to the land. In considering the development of the Ontario deposits the necessity of providing a market for the tailings or residues cannot be over-emphasized, since the ores are in general too poor to be profitably worked for the uranium-radium content alone.

A new use for radium is developing in the gem industry where it is used for colouring, decolourizing, or otherwise altering or improving the colour of precious stones. Apparently, however, such changes are not always permanent.

PRODUCTION

The world's total production of radium up to January, 1921, has been estimated by the United States Bureau of Mines at approximately 155 grams, or about 5 ounces. Of this the United States has produced 115 grams, which was obtained entirely from the carnotite and kindred ores of Colorado and Utah. Of the 40 grams produced outside of the United States, at least 10 grams are thought to have been made from American ore. A certain amount of carnotite ore is exported and at one time pitchblende ore produced from old gold mines in Gilpin county, Colorado, was sold in Europe.

It is impossible to obtain reliable data as to the amount of carnotite ore still available in the United States, for little drilling or deep development work has been done, and the workings are largely superficial and pockety. Probably, however, the greater part of the high-grade ore has already been exhausted. Writing in 1918 R. B. Moore, of the United States Bureau of Mines, stated that "In my judgment the carnotite fields will not produce more than 100 additional grams of radium element at the most—if that much. This would about double the world's present supply, but on account of the large use of radium in cancer treatment such an amount though large scientifically, would be small in proportion to the probable demands." Since this was written about 80 grams have been produced in the United States as follows: 1919—11·8 grams; 1920—32·5 grams; 1921—35 grams estimated.

In Europe radium has been produced in relatively small quantities ever since its discovery from the pitchblende deposits of Joachimsthal and from various localities in Saxony. Autunite ore (uranium-calcium phosphate) carrying 0·3 to 1 per cent U_3O_8 has been exploited in Portugal.

Two companies at least are mining for pitchblende in Cornwall and one is said to be producing very rich ore in commercial quantity. The pitchblende ore is associated in origin with the well-known tin deposits which have been worked since the time of the Phoenicians.

At Olary in South Australia a refractory low-grade ore containing much titanium and iron, with some rare earths, has been successfully worked.[1] The ore is concentrated, the concentrates comprising 30 per cent of the ore contain 1·6 per cent U_3O_8, so that the ore itself carries only 0·5 per cent U_3O_8. That there exists a commercially successful process for obtaining radium from an ore of this kind is of special interest as it appears that such lean and refractory minerals are on the whole of more common occurrence and more abundant in Ontario than the rich, easily refined uraninite. There is no record so far of a commercial production of radium based on uraninite from pegmatite.

The price of radium salts depends partly on the quantity purchased and partly on the purity of the product. On the whole, prices have been steadily rising since the beginning of commercial production. During 1921 the price in the United States was $115 to $120 a milligram of element for small lots. For larger quantities subject to competitive bids, prices were somewhat lower. The price may be stated as roughly from $3,000,000 to $3,500,000 an ounce. Radium is sold in the form of chloride or bromide, but the price is reckoned on the amount of element present as determined by electroscopic measurements of the gamma ray activity. Commercial preparations usually contain impurities, notably barium salts and possibly some mesothorium. The latter has properties similar to radium but decays in a few years. Mesothorium sells for $60 to $70 a milligram. A milligram is about $\frac{1}{31,000}$ ounce, Troy.

Owing to the scarcity of ores and the relatively high cost of mining and extraction it does not appear likely that the price of radium will decline, but rather otherwise.

GENERAL GEOLOGY OF THE RADIOACTIVE MINERAL OCCURRENCES IN ONTARIO

All discoveries of radioactive minerals in Ontario with the exception of a lost locality on lake Superior, have been in the area of Precambrian rocks south of French and Ottawa rivers and west of a line between Ottawa and Kingston. In this area there is an ancient highly metamorphosed sedimentary series consisting of crystalline limestones, quartzites, and paragneisses, which is intruded by a great variety of gneissic eruptives varying from granite to gabbros, anorthosites, nepheline rocks, etc. The sedimentary rocks have been called the Grenville and Hastings series and probably are equivalent in age to the great area of similar rocks which extends through Quebec to the Labrador coast. The limestones and paragneisses attain their greatest development in eastern Ontario. In the Parry Sound district the only crystalline limestone seen was in the neighbourhood of Seguin Falls. Particularly good exposures occur at Healey Falls on the road 6 miles north of Seguin Falls station, Grand Trunk railway. This is typical coarse crystalline limestone containing small crystals of pyroxene, phlogopite, and graphite, and appears to be exactly similar to the Grenville limestone in eastern Ontario and Quebec.

Throughout the area enormous quantities of pegmatite occur in dykes and intrusions of all shapes and sizes, from a few inches to 100 feet or more in width and 1,000 feet or more in length. The majority of the pegmatites are of the granite type in composition, consisting chiefly of potash and potash-soda feldspar and quartz with accessory minerals such as muscovite, biotite, hornblende, garnet, and various other minerals. Syenite pegmatites occasionally occur as at Craigmont and north of

[1] "Extraction of Radium from Olary Ores," by S. Radcliffe, Jour. Roy. Soc. of N.S. Wales, vol. 47, 1913.

Kingston. In general, three types may be distinguished, though where large exposures are available these structures are often seen to grade into one another.

(1) Segregated type: feldspar in solid crystalline masses often several feet in diameter with the quartz also in large pure masses and often moulded on large crystal faces of the feldspar.
(2) Graphic type: graphic intergrowth of quartz and feldspar. This intergrowth may be fine or coarse.
(3) Granitoid type: in which the feldspar and quartz occur as individual grains though often of large size. This appears to be simply very coarsely crystallized granite.

The above classification has been adopted as furnishing convenient designations applicable without qualification to most of the pegmatite exposures met with in the area examined. All these types of structure may sometimes be seen in one dyke, however, particularly if it be large and well exposed.

The largest dykes encountered, often from 50 to 200 feet wide and 1,000 feet or more in length, are as a rule of the graphic type and sometimes contain almost no minerals except quartz and feldspar. At other times much scaly white or black mica is present.

The smallest dykes, from a few inches to a few feet in width, are most often of the granitoid type. The segregated type occupies an intermediate position as to size. An example of the segregated type is shown on Plate II. The highest grade of crystal pottery spar is produced from dykes of the segregated type.

From observations so far made it appears that uraninite is most likely to be found in dykes of the segregated type, whereas complex minerals such as those of the euxenite group, niobates, tantalates, and titanates generally, and allanite, seem to be most at home in the graphic or granitoid type of pegmatite.

ECONOMIC MINERALS OF THE DYKES

FELDSPAR

The pegmatite dykes of Ontario and Quebec constitute probably the greatest reserve in the world of high-grade potash feldspar. The mining of feldspar has been for years a modest but growing industry and although the depression of the last two years coupled with excessive freight rates has for the time being reduced the output, it is none the less likely to become an important and stable industry. A reduction in railway and ocean freight rates would open up a very large market in England and the Continent. At present almost all our feldspar goes to the United States in the rough state and is ground there. Ground Canadian spar is even shipped back into Canada. In many cases there are small but sufficiently powerful and easily developed waterfalls near enough to deposits to permit of grinding the feldspar at very low cost. Feldspar as mined sells for $6 to $9 a ton on cars.

MICA

The radium-bearing pegmatites contain muscovite and biotite but not phlogopite (amber mica), which is the main source of the mica industry of Ontario and Quebec. White mica or muscovite has been mined for many years from the pegmatites of the area. The mica is usually somewhat dark coloured and sometimes shows black spots. These, however, are said not to affect its use in the electrical industry, which takes most of the production. Trimmed mica brings 50 cents to $10 a pound depending on size of sheets and quality. Black mica has within the last year become saleable and inquiries for considerable quantities have been received from the United States. The price offered is somewhat lower than that of scrap mica.

The white massive quartz of the segregated type of pegmatite has occasionally been sold, but it is worth only about $2 or $3 a ton and does not pay to ship. In many cases this type of quartz is of remarkable purity and should be suitable for fused silica ware, optical glass, or wherever an extremely pure silica is required.

RADIOACTIVE MINERALS

These minerals contain uranium or thorium or both and are mostly black or brown and rather heavy. If present in sufficient quantity they would constitute a valuable product. The most important ones found in Ontario deposits are:

Uraninite: Contains 70 to 80 per cent uranium oxide besides thorium, lead, and rare earths.

Euxenite-polycrase: May contain up to 10 or 15 per cent of uranium oxide with large amounts of titanium, tantalum, columbium, and rare earths. A little thorium is usually present.

Various other complex minerals occur. The mineralogy of the pegmatites has not yet been worked out in detail, but is in progress. Allanite, a silicate of aluminium, iron, and the rare earths, occurs in many of the dykes and in some cases shows considerable radioactivity, which is probably due chiefly to the presence of thorium.

It may be well to mention here the difference between uraninite and pitchblende. The latter term has been popularly applied to the mineral found in the Ontario pegmatites, but is not strictly correct. Pitchblende is a form of uranium oxide which is never found crystallized and which rarely, if ever, carries appreciable quantities of thorium and the rare earths. It occurs in metalliferous deposits such as those of Joachimsthal, Saxony, and Colorado. Uraninite, on the other hand, occurs as well-formed crystals of the cubic system, contains important amounts of thorium and the rare earths, and is found in granite pegmatite. Thus, though both minerals are essentially uranium oxide they are distinct in geological occurrence, composition, and to a certain extent, in physical properties.

If the rare minerals were to be separated from the feldspar and quartz by jigs or tables in all cases the resulting concentrates would contain several minerals, some of which would probably require a bisulfate fusion method of treatment such as used in the case of the Olary ores for extracting the radium or mesothorium. It would be impossible to produce pure radium from these minerals, as owing to the presence of thorium in the uraninite and other minerals the refined product would contain a certain amount of mesothorium. This, however, would not be objectionable for most uses.

Uranium, thorium, tantalum, columbium, titanium, and rare earth compounds could be obtained in some cases from such concentrates, often constituting valuable by-products.

It is impossible to say what price such a concentrate would bring, as there is none in the market, but some idea of the probable price may be obtained from the following quotation:

Carnotite ore,[1] per pound of U_3O_8—$1.25 to $1.75.

According to this quotation carnotite ore carrying 1 per cent U_3O_8 would be worth $25 to $35 per ton of 2,000 pounds. A concentrate carrying a higher percentage of U_3O_8 would be worth relatively more per pound of U_3O_8 than an ore carrying only 0·5 to 2 per cent. A rich uraninite concentrate carrying 25 to 50 per cent U_3O_8 should bring say $5 per pound of contained U_3O_8 as the refining costs on such a material would be much reduced.

INDICATIONS USEFUL IN SEARCHING FOR RADIOACTIVE MINERALS IN PEGMATITES

Radioactive minerals themselves are rarely if ever seen on weathered surfaces and can only be found by opening up the rock. The deep red colour shown by feldspar in the neighbourhood of such minerals, is, however, an almost infallible guide, which once seen is little likely to be mistaken for somewhat similar colours due to oxidation products of iron or manganese. Radioactive minerals do not attract a compass needle

[1] Chem. and Met. Eng., March 8, 1922.

and can thus be distinguished from magnetite or ilmenite, with which they might otherwise be confused in the field.

Another very characteristic indication is the presence of small cracks or fractures in the rock radiating from the mineral in all directions. These radiating fractures occur in feldspar, quartz, or mica surrounding radioactive minerals and are apparently caused by pressure which the mineral has exerted outwardly, due possibly to increase of volume resulting from internal radioactive changes. Such cracks are best seen in quartz. In mica they may take the form of six-rayed pressure figures. Finally, a small amount of pale yellow "bloom" or decomposition product may sometimes occur in the neighbourhood of the minerals, on fractures, etc.

The electroscope furnishes the most convenient test for radioactive minerals. It is unnecessary, however, for prospectors to purchase an instrument, since the services of the Provincial and Federal Mines Departments are always at their disposal. An ounce or less of material is sufficient for the test.

PARRY SOUND OCCURRENCES

Uraninite was discovered near Parry Sound, Ontario, in February, 1921, by James Robinson. The claims are now jointly held by H. F. McQuire and the Robinson brothers, all of Parry Sound. Other claims have since been located.

The McQuire-Robinson claims are included in the block comprised by lots 6 to 10, concessions IX and X, Conger township, Parry Sound district. This block lies between Blackstone lake and the Toronto-Sudbury line of the Canadian Pacific railway. The claims may be reached by a trail from Brignall flag station on the above line (12·8 miles southeast of Parry Sound) or by an old, partly overgrown settlers' road which starts in concession IX from the main road on the township line between Conger and Humphrey, and runs westward to Blackstone lake. None of the claims is more than a mile in a direct line from the railway (Figure 4).

The area is rocky, with numerous low hummocks or hills mostly less than 100 feet high. It is covered with thick small growth and some scattered hardwood. The drainage is towards Blackstone lake. The elevation is from 800 to 900 feet. There are no farms or clearings in the block.

The rocks are ancient Precambrian crystalline schists and gneissic eruptives probably of the same age as those of the Hastings-Grenville areas to the east. The larger hills are often mainly granite, whereas hornblende schists predominate in the valleys or lower ground. Masses of basic eruptive rock such as gabbro or norite also occur. Granite-pegmatite is abundant, forming dykes which are seen most often intruding the hornblende schists. The pegmatite dykes are found more often around the edges of the granite masses than in the masses themselves. Uraninite has been found only in the pegmatites, which represent the final products formed on the cooling of the granite masses.

It should be noted that this occurrence of radium-bearing minerals, as well as all others in Ontario, is of an entirely different type, both geologically and mineralogically, from the carnotite deposits now being worked in Colorado. The Colorado ore is a friable sandstone, a sedimentary rock, of Jurassic age, very much younger than the Ontario pegmatites, which has been more or less impregnated with the uranium-bearing mineral carnotite. Pure carnotite is a powdery yellow substance containing up to 55 per cent uranium oxide besides vanadium and other elements. The carnotite ore as mined runs from 1 per cent to 3 per cent uranium oxide according to some writers, but as it has been stated that 500 tons or more of the ore is required to produce one gram of radium, it would follow that the average tenor of the ore is probably somewhat less than 1 per cent uranium oxide.

In the case of the Conger Township occurrences the mother rock is of a very much older geological period, and has been produced by the cooling of masses of molten

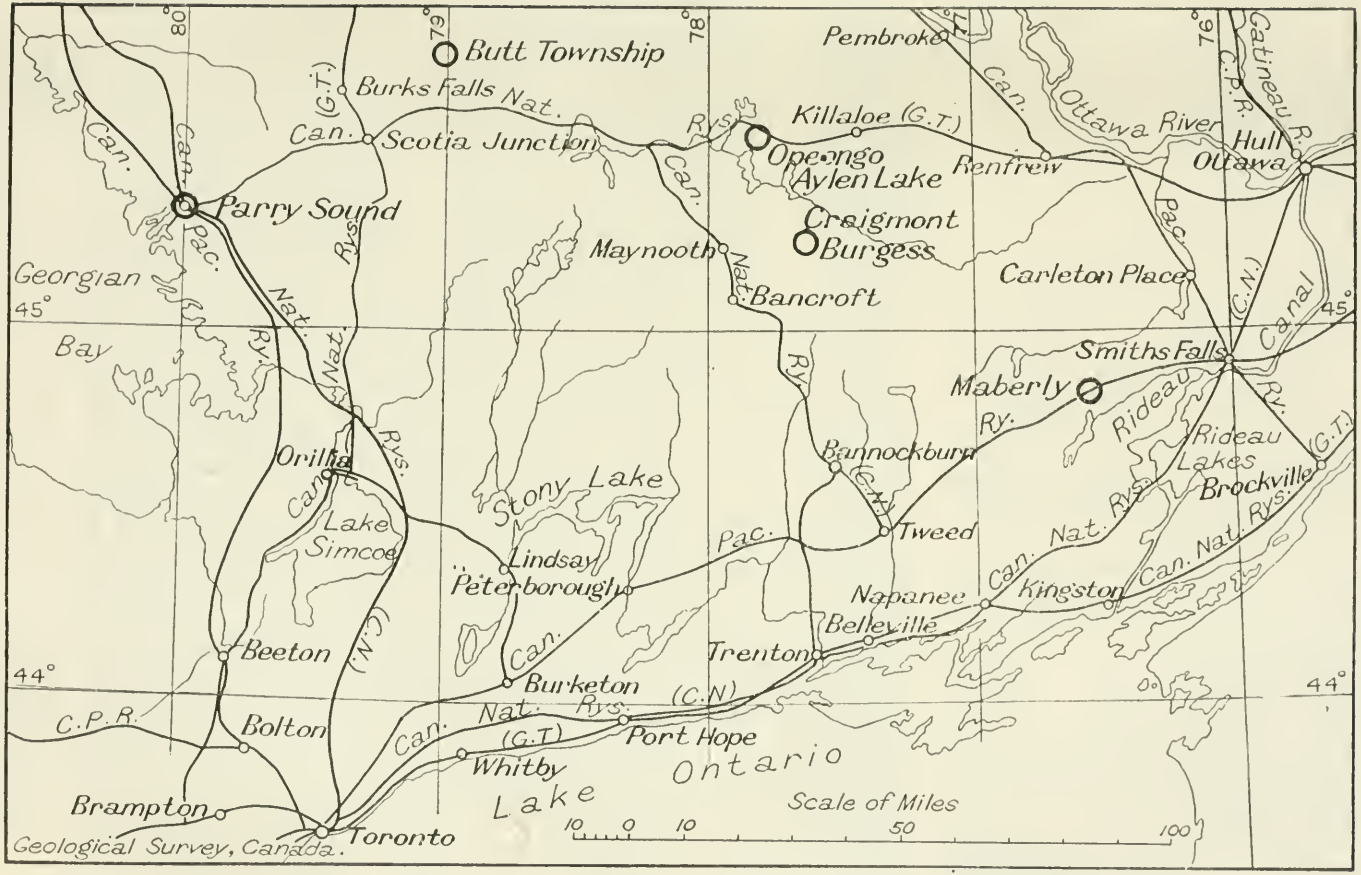

Figure 4. Index map showing locations of the principal known occurrences (in circles) of radioactive minerals in Ontario.

granite. The radium-bearing mineral is uraninite carrying up to 80 per cent uranium oxide. It is, therefore, richer in radium than the carnotite, since the radium content is proportional to the uranium present.

The granite of the area is noteworthy for the presence of numerous small manganese garnets, similar to those which occur in larger sizes in many of the pegmatite dykes. The granite is somewhat gneissoid, but, on the whole, is remarkably uniform in texture, and of a rather pleasing pinkish colour which is due partly to the oxidation of the garnets. It should make a good building stone, as very large blocks of uniform texture and colour could be obtained in certain localities. An analysis of a large composite sample from three different ridges yielded results as below:

	Per cent		Per cent
SiO_2	74·22	Na_2O	3·38
Al_2O_3	12·79	P_2O_5	0·01
Fe_2O_3	1·17	S	0·01
FeO	0·97	$H_2O+110°$ C	0·33
MnO	0·11	$H_2O-110°$ C	0·18
TiO_2	0·19	Ba, Sr; Zr, F	not detected
CaO	1·22		
MgO	0·38		
K_2O	4·99		99·95

The garnet granite is thus a typical granite with no special component except spessartite garnets. The connexion of the uraninite-bearing pegmatites of the district with this particular granite is well established by the occurrence of the same garnets in larger sizes in the pegmatites themselves. Strangely enough, there appear to be almost no garnet paragneisses in the immediate neighbourhood.

Minerals of the Dykes. The pegmatitic dykes consist chiefly of pink to red potash feldspar with from 25 per cent to 50 per cent of quartz. The quartz is of two varieties: (1) white and massive—usually very pure; (2) smoky and granular and mixed with feldspar, mica, etc. Both biotite (black) and muscovite (light) mica are found in large books in certain of the dykes. Uraninite occurs as isometric crystals or rounded grains, varying from ⅛ inch to 1 inch, but mostly ¼ inch or less in diameter. The usual crystal form is a combination of the cube and octahedron. It is found most often and most abundantly in intimate association with small white mica in a granular mixture of deep red feldspar and smoky quartz. It occurs less commonly alone in the feldspar and rarely in the massive white quartz of the pegmatites. The feldspar around the uraninite crystals is a deep red, noticeably darker than where uraninite is absent. This coloration of the feldspar is very characteristic, and important as an indication of the presence of radioactive minerals.

Red garnets of the manganese variety, spessartite, occur in some of the dykes, and a brownish, altered mineral in long crystals, sometimes several inches long, which qualitative tests indicated to be allanite. The allanite is somewhat radioactive and probably carries some thorium and uranium. One or more other rare minerals are also present, but the uraninite is the one of chief commercial interest. From several ounces of uraninite presented by Mr. McQuire, a representative sample for analysis was prepared by selecting apparently unaltered pieces from about thirty crystals or 'nuggets'. The uranium figures for such a sample will, of course, be higher than the general average, which should include the more or less altered uraninite. As, however, it was desirable to obtain results which could be used for determining the uranium-lead ratio, only the best pieces were selected. The analysis, which was conducted in duplicate with every precaution, yielded results as below:

	Per cent
Uranous oxide—UO_2	53·63
Uranic oxide—UO_3	26·32
Lead oxide—PbO	11·67
Thorium oxide—ThO_2	3·22
Yttrium group oxides	2·19
Cerium group oxides	0·98

		Per cent
Calcium oxide—CaO		0 41
Iron oxide—Fe_2O_3 / Aluminum oxide—Al_2O_3		0 17
Manganese oxide—MnO	present, less than	0 01
Silica—SiO_2		0 29
Water—H_2O		0 72
Insoluble		0 13
Magnesium oxide / Zirconium oxide / Bismuth oxide / Potassium oxide / Sodium oxide	Doubtful traces	
		99·74

Specific gravity 9·116 at 17·43° C.

The helium has not yet been accurately determined, but it is present in large amount. The total uranium element present is 69·19 per cent and lead 10·83 per cent. Using the latest data very kindly supplied the writer by Sir Ernest Rutherford the age of the uraninite works out as follows: $\frac{Pb}{(U + 0.38\ Th)} = 1.21 \times 10^{-10} \times t$ where t= the time in years. Inserting the figures for lead, uranium, and thorium we obtain: $0{\cdot}154 = 1{\cdot}21 \times 10^{-10} \times t$ or t= 1,272,000,000 years. The age of the granite is thus indicated to be 1,272,000,000 years and the series of rocks intruded by the granite is, of course, still older.

An interesting feature is the occurrence of a material resembling anthraxolite in association with the uraninite. This is a lustrous black substance consisting chiefly of fixed carbon, which burns apparently without giving off any volatile hydrocarbon and leaves a small amount of blackish residue. The residue is rich in uranium. The occurrence of this carbonaceous material may have an important bearing on the origin of uraninite.

Feldspar of excellent pottery grade occurs in several of the dykes and the graphic type of material consisting of an intergrowth of quartz and feldspar occurs in very large bodies hundreds of feet in length.

Large sheets of white mica could be obtained from certain of the dykes and would be a valuable product. The mica is of excellent quality except for the rather common occurrence of black spots, which, however, probably would not be objectionable for many electrical uses. In most cases these black spots seem to be minute and extremely thin included crystals of black mica, which probably do not appreciably affect the insulating qualities of the muscovite. Perfectly clear large sheets have been obtained, however, and these would sell for high prices. Black mica occurs in several of the dykes and is now saleable at about the price of scrap mica.

The best showing of uraninite is in the dyke on the line between lots 9 and 10, concession IX, near a bay of Blackstone lake (Plate I). The dyke is exposed on the side of a hill for a length of 70 feet. Its width over the rounded side is 50 to 60 feet, but the true width is not ascertainable as the dip or inclination is not known. It rises to a vertical height of perhaps 40 feet above a swampy creek gully. Nearly one-half of the exposed surface consists of massive white quartz, with a small amount of pink spar. The other half consists of mixed, smoky quartz, pink to red feldspar, and small white and black mica. Uraninite occurs as scattered grains chiefly in this area at or near the contact of this area with the massive quartz, particularly in association with stringers of small mica books. In August, 1921, several shots had been put in over the face and one pocket included within an area 2 feet square showed very abundant grains and crystals of uraninite from ⅛ to ½ inch diameter set in irregularly packed small white mica. This area would certainly make very rich ore and if such pockets could be found with sufficient frequency they would serve to enrich much of the poorer rock.

Large sheets of white mica have been taken from this dyke and probably more might be obtained.

Six other dykes have been to some extent opened up and show scattered small grains of radioactive mineral, probably uraninite. Some of these dykes carry a very good grade of feldspar, and might be worth working for spar, bearing in mind the chance of striking rich pockets of uraninite.

It is difficult to estimate in the absence of large-scale sampling how much ore of commercial grade could be produced, but a rough idea may be obtained by determining what area of uraninite must be visible on exposed faces of the rock, in order to give ore of any determined percentage.

Taking the average specific gravity of the rock as 2·6 and of the uraninite as 8·86 and the average U_3O_8 content of the uraninite as 80 per cent we arrive at the result that in order to have say 0·5 per cent U_3O_8 ore, each cubic foot of rock must contain on the average 1 pound or 3·1 cubic inches of uraninite. If then the uraninite were uniformly distributed throughout a cubic foot of rock cut into forty-eight imaginary slices each ¼ inch thick and 1 foot square each slice would contain on an average, 8 cubes of uraninite each ½ inch on the side. We thus obtain some idea as to the amount of uraninite that should be visible on rock faces for any grade of ore. Similar rough calculations may be applied for euxenite and other minerals.

Other claims examined are those of Dr. Milton Armstrong, Parry Sound, on lot 6, concession X, Conger township; C. C. Calverly of Parry Sound, lot 5, concession VII, Conger township, and the farm of Moses Smith, south of Parry Sound. Little work had been done on these, but some scattered grains of radioactive minerals were visible.

Seguin Falls. Two days were spent in the neighbourhood, and dykes containing allanite discovered by D. Hall and A. MacKinnon were examined. As no mines were in operation only a short time was spent in the locality.

BUTT TOWNSHIP OCCURRENCES

Butt township, Nipissing district, is reached by a road from Kearney, on the Grand Trunk railway, 6 miles east of Scotia junction. The area is just west of the western boundary of Algonquin park. The road can be traversed by automobile as far as the Fish shacks on Maganatawan river (lot 28, concession VI, Proudfoot). From there a winter log road leads to what is called No. 2 camp, an old logging camp on lot 1, concession VI, Butt township. From No. 2 camp trails have been made to the various claims. Although the claims are by the existing road 20 to 25 miles from the railway, it is believed that a short cut nearly due south is practicable and would reduce the distance to 6 or 8 miles.

The country is rough and hilly. The elevation of the highest hills in Butt is about 1,600 feet above sea-level, and the hills may be as much as 300 feet above the valleys. There is a heavy covering of yellowish glacial sand, so that rock exposures are rarely seen except on the steep sides of hills. The forest consists of heavy second growth with considerable good hardwood, particularly birch, in places. The sand and second growth make prospecting difficult, and the claims even as so far developed represent a great deal of hard work.

Essentially the same series of rocks occur as at Parry Sound, as far as can be judged from the few exposures. Garnetiferous granite like that at Parry Sound was observed at several places. Biotite and hornblende gneisses, often garnetiferous, are common and one or two small exposures of quartzite were seen. The general trend of the rocks is northeast-southwest. A majority of the pegmatite dykes strike from 20 degrees to 90 degrees east of magnetic north and often dip to the northwest. Dykes of the segregated type are common and sometimes are remarkably regular and veinlike in outcrops (Plate II), though when such dykes can be seen in any degree of completeness in two dimensions they prove to be really lens-shaped. The dykes are largest and best developed when they intrude mica or hornblende gneisses. Those which occur in granitic gneisses are mostly small, often not more than a foot wide. Basic irruptives, sometimes giving rise to small deposits of pyrite and pyrrhotite, occur. A few miles east of Burks Falls a shaft was sunk and nickeliferous pyrrhotite was mined about twenty years ago. No crystalline limestone or indications of its presence were seen in this area.

Wm. Elliott Claim. The first uraninite discovered in Ontario came from the mica mine of Wm. Elliott, situated on the south half of lot 13, concession VII, Butt township. The occurrence has been well described by C. W. Knight of the Ontario Bureau of Mines[1] and there is nothing to add to his description. At the time of the present writer's visit the dyke was exposed for a length of 90 feet and is probably about 10 feet wide. The strike is north 30 degrees east magnetic and the dip is uncertain. The dyke is a granite pegmatite of the segregated type carrying a considerable quantity of white mica. Masses of white quartz and pink feldspar occur up to 3 feet in diameter. The spar mostly carries white mica. In addition there are areas of a granular mixture of deep red spar, smoky quartz, and small books of white mica just as in the uraninite dykes at Parry Sound. In this mixture small brownish allanite (?) crystals are fairly common and scattered grains of uraninite up to ¼ inch in diameter were seen. Some of these were collected. The uraninite sometimes occurs also in the more massive feldspar. Books of dark-coloured muscovite up to 5 and 6 inches diameter occur plentifully in the feldspathic areas. The mine was originally opened and worked for mica.

Bullock Claim. North half lot 11, concession VI, Butt township, owned by Mr. Bullock, of Chicago.

The dyke was opened for mica, and some good large books are said to have been obtained. The opening is a cut about 12 feet in diameter and 12 feet deep at the back, in pegmatite on the side of a hill. The dyke consists almost wholly of large solid masses of white quartz and pink potash spar with perhaps 10 per cent of the mixture of granular smoky quartz, red feldspar, and white mica. Red manganese garnets up to an inch in diameter, and ilmenite, are common. The garnets are particularly abundant in the granular mixture, but may occasionally be seen in both the massive white quartz and spar areas. There is little or no evidence of the presence of radioactive minerals. On the hill north of the cut there are some small rock exposures of the garnet-granite type. Other openings on the Bullock claims are not promising for radioactive minerals.

Mining Corporation Claims. North half of lot 14, concession VII, and south half of lot 14, concession VIII, Butt.

Shortly after the discovery of uraninite on the Elliott claim, the Mining Corporation of Cobalt became interested in the district, took up several claims, and did considerable trenching apparently in the hope of finding a narrow vein in which the uranium values might be more concentrated, as in some of the Colorado pitchblende veins. They uncovered a pegmatite vein about 350 feet long varying in width from 2 inches to a foot, and averaging 8 inches, which is remarkable for its regularity in length and width. Though vein-like in form it has a typical pegmatite filling consisting of feldspar and smoky quartz in about equal amounts with a little scaly black and white mica, and rather abundant garnets and ilmenite. No openings were made in the vein, but it was stripped along almost its full length. There are in places some slight indications of the presence of radioactive minerals in the way of red coloration, but none were actually seen. Coming up the hill from the west large exposures of typical garnet-granite are seen not far from this vein.

A. E. Trafford, Sundridge, Ont., Claim. South half lot 11, concession VII, Butt.

The dyke is 8 to 10 feet wide and 70 feet long striking north 15 degrees east magnetic. Openings show medium to coarse-grained spar and quartz with much black mica. No smoky quartz is present. Some small brown crystals, probably allanite, and some indications of radioactive minerals were seen.

A. E. Trafford Claim. North half lot 10, concession VII, Butt.

This is a dyke 18 inches to 2 feet thick lying on coarse foliated hornblende gneiss on the side of a hill, dipping at about 45 degrees to the northwest under drift, and

[1] Knight. C. W., Can. Min. Jour., Oct. 14, 1919.

exposed by stripping for 40 to 50 feet up the hill. The exposed surface is really the wall of the dyke smoothly glaciated. The pegmatite is a mixture of medium-grain pink to red feldspar and quartz with white and black mica in books up to 3 or 4 inches diameter. There is some of the granular smoky quartz, deep red spar, and small mica mixture. Some scattered grains of radioactive mineral up to $\frac{1}{4}$ inch diameter were seen.

Frank Watson, Kearney, Claim. North half lot 10, concession VI, Butt.

A small stripping shows dykes 12 to 24 inches wide of pink spar, quartz, and small black mica. Some small brown crystals, probably allanite, were seen.

F. H. Armstrong, Kearney, Claim. South half lot 8, concession IX, Butt.

A stripping shows pegmatite 3 to 4 feet wide and 40 feet long striking due east and west, magnetic. The dyke is of the segregated type with 1 foot to 18 inches of massive white quartz in the middle and pink potash spar at the sides. Books of altered chloritic biotite up to 2 inches diameter occur in the spar. Magnetite or ilmenite and a few small brownish crystals up to an inch long, probably allanite, occur. No white mica or garnets, and only a little smoky quartz, were seen.

C. W. Beaton, Kearney, Claim. South half lot 7, concession IX, Butt.

A stripping shows a dyke 1 to 2 feet wide, exposed for 15 feet, striking east and west magnetic. A pit 8 feet long, 4 feet wide, and 8 feet deep has been sunk exposing light to pink spar with about one-third quartz and a little altered biotite. Ilmenite, a few small crystals, probably of allanite, and a little titanite were seen. No white mica, little or no smoky quartz, and but little deep red spar were seen.

R. G. Armstrong, Kearney, Claim. South half lot 7, concession X, Butt.

A stripping on the west side of a hill shows three pegmatite dykes from 1 to 3 feet wide converging at the bottom and exposed for 20 to 50 feet up the hillside. The pegmatite consists of pink potash spar and white quartz with a little black mica. Some small black crystals of a pitchy lustre surrounded by dark red spar were seen.

Napoleon Dault Claim. North half of lot 4, concession VI, Butt.

This interesting lens-shaped dyke, shown on Figure 5, exhibits on a small scale what appears to be the characteristic form of the dykes in this district if complete sections were available. It strikes due north and south magnetic, is about 6 feet wide at the thickest part in the middle, and tapers rapidly to nothing at both ends, the total length being 100 feet. There is a lens of white massive quartz 18 inches

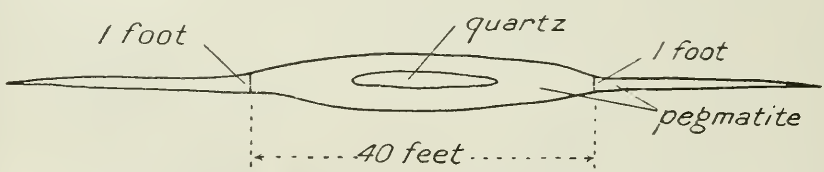

Figure 5. Diagram showing dyke on claim of Napoleon Dault.

wide in the middle of the widest part. The pegmatite is largely fairly coarse pink potash spar with some soda lime spar. Some smoky quartz and a little black mica up to 3 inches diameter occur and masses of magnetite or ilmenite up to 3 or 4 inches in diameter may be seen in the thickest part. Red garnets are abundant in places. Some brownish crystals, probably allanite, up to 1 inch long, were seen, and in some parts a little deep red feldspar.

John Ryan, Kearney, Claim. South half lot 6, concession VI, Butt.

A stripping shows a dyke 3 feet wide dipping 40 degrees to the northeast, consisting of about 80 per cent pink potash spar mixed with white and smoky quartz. Scattered grains of radioactive mineral occur. Another dyke on the same claim is 1 foot to 18 inches wide and the wall is exposed by stripping as a flat surface about

30 feet up the hillside. It consists of about 80 per cent deep red spar with some smoky quartz and a little scaly black and white mica. Nuggets of radioactive mineral up to ½ inch diameter were quite abundant in one place where it had been opened up.

Claim lot 7, concession VI. A dyke 4 to 10 feet wide on this claim consists chiefly of pink spar with some white and smoky quartz and black mica. There is some evidence of the presence of radioactive minerals in the deep red spar and Mr. Ryan states that some grains of radioactive minerals have been found here.

W. H. Ryan, R. A. Mann, and D. J. Sheehan of Kearney, Claims. Lots 1, 2, 3, concession VI, Butt.

Traversing these claims in a nearly east and west direction is a large dyke which is better exposed and more opened up than any others examined in the district and will, therefore, be described in more detail. Its western extremity may be seen in vertical section exposed on an almost perpendicular hillside 40 or 50 feet high on lot 1. It here dips at 35 degrees to the north and cuts through foliated micaceous gneiss which strikes about due north and south. The dyke is 2 feet wide at the bottom of the hill, the width gradually increasing toward the top where it is 8 feet wide. It consists there of a coarse granular mixture of about 75 per cent reddish potash spar and quartz. A small amount of black mica in books up to 3 inches across, and a little smoky quartz, are present. No radioactive minerals other than small brownish allanite crystals were seen here. Three hundred feet east of this outcrop a stripping 40 feet long shows the dyke to be 6 feet wide and much coarser in texture. It contains masses of white quartz 2 or 3 feet in diameter which have a tendency to occur in the middle of the dyke with the spar similarly segregated at the sides. Black mica and some brownish allanite crystals occur here also and the owners state that a few grains of other radioactive minerals were obtained. Four hundred feet farther east (lot 2) on top of the hill—which rises 300 feet above the valley—another stripping exposes the dyke for 80 feet. It is here 6 to 7 feet wide and the quartz and spar are almost completely segregated. Masses of white quartz up to 2 feet wide fringed with patches of smoky quartz occupy the middle of the dyke with large crystals of spar which occasionally extend from side to side. The spar contains a little intergrown quartz and some black mica. A pit 15 feet long and 10 feet deep at the eastern end of the stripping shows that the dip is still 35 degrees to the north. Allanite and other radioactive minerals occur; the allanite chiefly at the edge of the dyke next the country rock, and other minerals at the contact of the smoky quartz and spar in the middle of the dyke. Two hundred feet east of this last outcrop, and still far up the hill, the dyke is again exposed for 50 feet. It is here about 10 feet wide. A pit 10 feet diameter and 15 feet deep has been sunk at the east end of the stripping. Segregation of the spar and quartz is almost complete, the quartz occurring in the middle in solid pure white masses, the spar on both sides and sometimes extending completely across the dyke and cutting off the quartz masses. The quartz is often moulded on large crystal faces of spar a foot or more across. Radioactive minerals are more abundant here than at any of the outcrops previously noted and the brown, waxy allanite crystals here attain their greatest size. They are as much as 1½ inches wide and 8 to 10 inches long and occur as usual in the spar next the walls. Smoky quartz, black mica up to 3 inches diameter, pyrite, a little chalcopyrite, and a few garnets occur.

About 17 or 18 chains east of this outcrop the dyke is again exposed by stripping for about 100 feet. This is on lot 3. The dyke here has a very uniform width of about 15 feet and is remarkable for its regular vein-like structure. The pure white quartz occurs as an uninterrupted band 5 to 7 feet wide in the middle with the spar equally developed on both sides (Plate II).

A pit 10 feet square and 15 feet deep shows that the dyke still dips to the north and becomes narrower as it goes down. Nuggets of radioactive minerals up to an inch in diameter, seen in the walls of the pit, are mostly associated with small white

mica in the spar, but also occur in solid spar and in solid quartz. Small garnets, pyrite, and chalcopyrite are sparingly found. The radioactive minerals probably are chiefly of the complex type. They are at present under investigation. East of this exposure the dyke disappears into low ground and has not been traced farther east.

This very interesting dyke is evidently a portion of a lens-shaped body duplicating on a larger scale features shown by the small dyke on the claim of Napoleon Dault, previously described. Allanite (showing alpha-ray activity equivalent to as much as 3 per cent U_3O_8, but probably due mostly to thorium) occurs throughout the length of the dyke, but the richer minerals are almost confined to the highly segregated central portion.

An interesting feature not previously mentioned in connexion with this dyke is the evidence of plastic movement of the dyke body in a direction from west to east. This is shown by drag structures on the walls of partly assimilated country rock.

Mr. W. H. Ryan showed to the writer certificates of assays by John H. Banks and Son, 26 John St., New York, on three grab samples of the deep red feldspar as mined from the dyke on lots 2 and 3. Results: No. 1, 0·26 per cent; No. 2, 0·37 per cent; No. 3, 0·45 per cent of uranium oxide, U_3O_8. No. 3 sample was said to be across 3 feet of the spar on lot 3. A report by the same chemists, on concentration tests on another sample, is reproduced, in its essentials, below:

"Ore as received assayed 0·18 per cent U_3O_8.

Sample was crushed to pass 10 mesh and divided as follows:

Through 10 on 16 mesh
" 16 " 30
" 30 " 40
" 40 " 60
" 60 ..

Each of the above sizes was concentrated separately on a Wilfley table with the following results:

Ore		Concentrates		Tails
Mesh	Weight	Weight	Assay U_3O_8	Weight
−10 + 16	3,562 g.	51 g.	0·99%	3,511
−16 + 30	2,230	929		2,138
−30 + 40	685	12		673
−40 + 60	1,730	27	2·36%	1,703
−60	1,140	7		1,133
Totals........	9,347	189	1·32%	

Weight of U_3O_8 in ore treated.. .. .. 16·82g.
Weight of U_3O_8 in concentrated.. .. .. 2·50%
Recovery U_3O_8.. .. .. 14·8 %"

It seems improbable that the recovery was actually as poor as indicated by these figures in view of the results obtained by the Ore Testing Division, Mines Branch, in concentration tests on the Maberley euxenite (page 68). The accurate determination of uranium in an ore of this nature by chemical methods is extremely difficult and on such low-grade material the analytical errors are relatively large and might easily account, partly at least, for the apparently very poor recovery.

The occurrences described are typical of the Butt district. A considerable number of dykes examined need not be mentioned here as they are not particularly noteworthy, though in many cases a few small scattered grains of radioactive minerals have been found. The exact analysis of the Butt Township uraninite has not yet been completed, but preliminary results indicate that it is of the same composition and age as the Parry Sound material, containing about 10 per cent of lead.

OPEONGO-AYLEN LAKE OCCURRENCES

From Kearney the writer proceeded eastward across Algonquin park (where prospecting is not permitted by the Ontario Government) and examined the mines and pegmatites in the vicinity of Opeongo and Aylen lakes. These places are flag stops on the Grand Trunk railway between Madawaska and Barry Bay. Hotel accommodation may be had at Barry Bay or Madawaska.

In this district two dykes have been worked for feldspar, and from another dyke on the Aylen Lake peninsula 60 or 65 tons of mica is said to have been obtained. Claims have been staked from time to time for feldspar or mica, but no radioactive minerals had been noted in the district, and apparently no prospecting for such minerals has been done. Thanks to the kindness of Mr. F. G. Armstrong of the Opeongo Lumber Company, the writer was enabled with a minimum of time and trouble to see a large number of dykes, and radioactive minerals in small amounts were discovered in many cases and some indications of their presence in nearly all cases. A hurried examination of the specimens collected has not so far disclosed any uraninite, but some of the specimens show a considerable alpha-ray activity. The district appears to be favourable for the production of feldspar and mica. Granite pegmatites of all types occur, including the segregated type described in some detail under the Butt Township occurrences. Dykes of this type, carrying the highest grade of crystal potash spar, were seen. Garnet granite-gneiss, biotite, and hornblende-schists and basic irruptives occur, as at Parry Sound and in Butt townships. No crystalline limestone was noticed.

CRAIGMONT-BURGESS OCCURRENCES

A few days were spent in Craigmont and vicinity. Here the pegmatites are chiefly of the syenite variety as to composition, being almost quartz free, and of the granitoid type as to structure. The greater part of the corundum produced at Craigmont is said by Mr. E. B. Clarke, manager of the Manufacturers Corundum Company, to have been obtained from such dykes rather than from the nepheline rocks, and this is further evidenced by the old workings. A considerable quantity of dark minerals was collected from the old dumps and alpha-ray tests show that these are mostly radioactive in some degree. Similar minerals were fairly common on the dump of the Burgess mine, and are also radioactive. No detailed examination of these samples has been made.

Some years ago the old concentrating mill burned down, and subsequently a quantity of concentrates which had been in the fire were put through the new mill. Among the heaviest materials coming off the tables was a mixture of lead pellets the size of No. 8 shot or smaller, along with fused sulphides, magnetite, etc., on which Mr. Clarke, probably at the instance of Sir Stopford Brunton, had tests made for radioactivity, first at McGill University and later in the United States. In both cases it was reported to be slightly radioactive. Mr. Clarke kindly presented the writer with a sample of this concentrate and examination under the binocular has revealed a few small grains of material which chemical and alpha-ray tests show to be unquestionably uraninite. From the nature of the dykes one would be inclined to doubt the occurrence of uraninite, but the finding of radioactive minerals on the dump rather favours the possibility.

MABERLEY OCCURRENCES

Orser-Kraft Feldspar Mine. The occurrence of euxenite in this mine was described by W. G. Miller and C. W. Knight.[1]. Mining has continued since then and a large amount of feldspar has been shipped. The dyke is essentially of the graphic type, grading into a somewhat segregated phase at the eastern end, and at

[1] Miller, W. G., and Knight, C. W., 26th Ann. Rept., Ont. Bureau of Mines, 1917.

depth. Nearly all the feldspar produced has gone to makers of household scrubbing powders, but since getting into the segregrated parts some first-class crystal spar is being mined which would be suitable for pottery and enamel work. The opening is now nearly 200 feet long, 60 feet wide at the top, and 30 to 40 feet deep. The dyke strikes north 75 degrees east magnetic and dips slightly to the south.

Euxenite has been fairly abundant during the whole period of mining, according to Mr. S. H. Orser. At the time of the writer's visit considerably more euxenite was visible than when the dyke was opened up some years ago. Black tourmaline occurs abundantly in some parts of the dyke, particularly at the western end. In some cases euxenite may be found in the centre of tourmaline crystals, showing that it was one of the earliest minerals formed. The feldspar around the euxenite is a very deep red in contrast with the lighter tints of the spar where it is absent. This deep red of the feldspar, first observed here, is characteristic of all the pegmatite occurrences of radioactive minerals so far found in Ontario, and, when well marked, is an almost infallible indication of the presence of such minerals. The cause of this coloration is under investigation.

During the winter Mr. Orser sorted out a quantity of the red feldspar containing euxenite, and submitted it to the Ore Testing Division for concentration. The particulars of this test have been supplied by W. B. Timm, Chief, Division of Ore Dressing and Metallurgy, and may for convenience be given here:

Test No. 159

"A shipment of euxenite ore weighing 1,593 pounds net was received on November 29, 1921, from the Orser-Kraft Feldspar, Limited, Box 266, Perth, Ont. The ore came from the company's property at Maberley, Ont., and consisted of fair-sized crystals of black euxenite in red orthoclase feldspar.

It was desired that the euxenite be separated from the feldspar and that both be recovered in the form of clean products.

A number of specimens were picked out of the ore and the remainder was reduced in a jaw crusher to ¾ inch.

Product	Weight, pounds	Per cent of pounds
—¾ inch	1,582·00	99·80
Loss	3·25	0·20
Heads	1,585·25	100·00

The ¾-inch material was crushed in rolls and then screened on 12 mesh by a shaking Ferraris screen, the oversize from the screen being fed back to the rolls until it all passed through the screen.

Product	Weight, pounds	Per cent of heads
—12 mesh	1,472	92·86
Loss	110	6·94
—¾ inch	1,582	99·80

The −12 mesh material was sized on a Keedy sizer into four sizes: −8+20; −20+42; −42+86; and −86.

Product	Weight, pounds	Per cent of heads
− 8 + 20	394·0	24·86
− 20 + 42	535·5	33·78
− 42 + 86	260·5	16·43
− 86	267·0	16·84
Loss	15·0	0·95
−12 mesh	1,472·0	92·86

Each of the four sizes from the Keedy sizer was tabled separately on a large Wilfley table, so as to make a euxenite concentrate and a feldspar tailing of each size. These products were collected as they came from the tables in long settling boxes. The water from the tailing box was pumped to a callow cone during the tabling of all the different sizes, and by this means a certain amount of slime was removed. After tabling all products were dried and weighed. The four concentrates produced were very good, being nearly all euxenite, with only a small percentage of feldspar. The tailings were composed of clean feldspar. The slime from the Callow tank was very fine, and drab in colour, and under the microscope was seen to be made up mostly of feldspar with a little euxenite.

Product		Weight, pounds	Per cent of heads	
Concentrate	− 8 20	14·00	0·89	3 67
"	−20 40	23·50	1·48	
"	−42 86	10·50	0·66	
"	−86	10·12	0·64	
Tailing	− 8 20	370·00	23·34	83·45
"	−20 42	504·00	31·79	
"	−42 86	244·00	15·39	
"	−86	205·00	12·93	
Slimes		42·00	2·65	
Loss		83·88	2·14	
Feed to table		1,457·00	91·91	

The concentrate, after sampling, and a sample representing in proper proportions the combined four sizes of tailings, were shipped to the Orser-Kraft Feldspar, Limited, Perth, Ont.

Summary and Conclusions. The euxenite concentrate produced equals 3·67 per cent of the ore treated.

The feldspar tailing product equals 83·45 per cent of the ore treated.

The slimes produced equal 2·65 per cent of the ore treated.

The loss in treatment equals 10·23 per cent of the ore treated.

A good separation of the euxenite from the feldspar can be made. Good clean products can be produced.

Dry crushing and tabling is a very suitable method of treating the ore, as submitted."

Samples of the various concentrates were mixed in the proper proportions to represent the whole, and on analysis yielded the following results:

	Per cent
U_3O_8	5·7
ThO_2	2·30
Cerium group earths	0·48
Yttrium group earths	16·31

A more complete analysis is being made, the above results being of a preliminary nature. The concentrate contains in addition large amounts of columbium, tantalum, and titanium, besides iron, alumina, silica, sulphur, phosphoric acid, and other common elements. Several rare minerals are present, one of which is probably xenotime.

Ground samples of the tailings and slimes were tested in the alpha-ray electroscope against the analysed concentrate with the following results:

Tailings................alpha-ray activity practically nil
Slimes..................alpha-ray activity $\frac{1}{178}$ that of concentrate

The slimes, therefore, carry about 0·04 per cent of $U_3O_8 + ThO_2$ or about 0·03 U_3O_8 and 0·01 per cent ThO_2, and the separation from the tailings is practically 100 per cent complete. Thus on a ton of 2,000 pounds the recovery was 73·4 pounds of concentrates containing 4·18 pounds U_3O_8 and 1·68 pounds ThO_2, and 53 pounds of slimes containing 0·02 pounds U_3O_8 and ThO_2. The ore, therefore, carried about 0·2 per cent U_3O_8 and 0·08 per cent ThO_2.

The results of this test on the whole have been encouraging. The recovery has been excellent. The tailings constitute a feldspar product of saleable quality due to the elimination of iron-bearing impurities and their increased value might on the commercial scale pay for the cost of treatment.

Radioactive minerals were found in small quantity in several other dykes in the Maberley district. Some nuggets of euxenite an inch or more in diameter were seen in a large detached block of a dyke on the same lot as the Orser mine. Between Sharbot lake and Kingston on the Kingston and Pembroke railway, especially around Verona and Tichborne, is probably the most active feldspar mining district in Ontario. Most of the mines were visited, but radioactive minerals are apparently of rare occurrence in this district. The specimens collected here have not yet been tested. They are mostly small, and, probably in many cases, are allanite.

GENERAL CONCLUSIONS

The pegmatites of Ontario undoubtedly contain, in the aggregate, a relatively enormous amount of radium and thorium minerals, but these occur in a widely disseminated condition, and, to the writer, it appears improbable that rich concentrations will ever be found in commercial amount in this type of occurrence. Low-grade ore containing a pound or two of uranium oxide to the ton might, nevertheless, under certain conditions, prove workable, the tailings constituting a refined ground feldspar product that would be the main source of revenue, while the uranium minerals would be a by-product obtainable, probably, at little extra expense. It would unquestionably pay producers to market their feldspar in the ground condition. The application of a concentration process would remove not only the radium minerals, but also various highly objectionable impurities such as magnetite, ilmenite, pyrite, tourmaline, black mica, etc., thus improving the quality of the feldspar product, and enabling deposits to be worked on a large scale with little or no expensive hand-picking and sorting. The presence of some quartz in such a feldspar product would, probably, not be objectionable for most uses, provided uniformity of composition were maintained, and this can be done easily by working on a large scale.

Such operations, however, could probably be successfully carried on only by a company with capital sufficient to produce and market ground feldspar in large quantities, mine mica, and recover and refine the rare mineral by-products.

GEOLOGY OF LEMIEUX TOWNSHIP, GASPE COUNTY, QUEBEC

By F. J. Alcock

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INTRODUCTION

Gaspe peninsula was the scene of the first work of the Geological Survey, Canada. The founder of the Survey, Sir William Logan, explored it for coal. His assistants mapped a number of its rivers. In more recent years detailed stratigraphical work was carried out along its eastern coast. The interior, however, has to a large extent remained an unprospected region, chiefly on account of the difficulties of travel and supplies. The discovery in 1910 of zinc and lead deposits near the headwaters of Berry Mountain brook, a tributary of Cascapedia river, revived interest in the mineral possibilities of the peninsula, and the development of these deposits led to a demand for more detailed knowledge of the geology of the surrounding area. The present report is the result of work during the field season of 1921, with the new zinc and lead field as a central point.

FIELD WORK

A transit and stadia control was carried up the road from bench-mark 1309·95, 3 miles south of the Federal mine. This bench-mark was derived from the surveyed line between Matane and Gaspe counties. The elevations were all derived from this control. The detailed map around the Federal Zinc and Lead mine was made by plane-table and alidade; the areal map was compiled from traverses made with chain, compass, and barometer away from the transit and stadia control lines. Barometer readings were corrected daily from the records of a camp barometer. The trail from the Federal mine to lake Ste. Anne, a trail along Brandy brook, another down Ste. Anne river, and still another up the valley to the southwest of lake Ste. Anne were most useful as controls for the side traverses.

ACKNOWLEDGMENTS

The writer is indebted to the officials of the Federal Zinc and Lead mine for their courtesy and kindness in facilitating the work in every way in their power. Since no underground work had been done recently the lower level of the mine was filled with water and at considerable expense to themselves, the company had this pumped out so that all the workings might be examined. To Mr. J. C. Beidelman, Vice-President and General Manager of the Company, special thanks are due for the generous gift of specimens, information concerning the mine and surrounding country, the use of mine buildings, maps, mine plans, reports, etc., and for other courtesies extended to the writer.

Assistance in the field was efficiently rendered by P. G. B. Gilbert and H. R. Cromwell.

LOCATION AND AREA

The area (Figure 6) comprises approximately 70 square miles and lies in the central part of Gaspe peninsula on the divide between the waters flowing about 25 miles (as the crow flies) north to the St. Lawrence and those flowing south about 40 miles (as the crow flies) to Chaleur bay. The area, though nearer the St. Lawrence, is more easily reached from the south, by which route Shickshock mountains are avoided.

MEANS OF COMMUNICATION

The Quebec Oriental railway follows the south shore of Gaspe peninsula eastward from Matapedia on the Intercolonial railway. A wagon road 45 miles in length connects Cascapedia, on the Quebec Oriental, and the Federal mine. The road, for 35 miles, follows the east bank of Cascapedia river and then skirts the west side of Berry Mountain brook. For most of the distance the road follows an old lumber road, but so much work has been done by the Federal mining company in improving the grade, building bridges, etc., that the present road is practically a new one. Much work still remains to be done, however, before it can be used for extensive summer transportation.

Camps are situated at convenient intervals along the road. The first is at Escuminac 5 miles above Cascapedia station. A survey of the road made for the Federal company begins at the township line between New Richmond and Flahault, which crosses the Cascapedia one mile above the company's buildings at Escuminac. The other camps along the road are: Joe Martin camp near milepost 10; Tracadie near milepost 15; Douglas at mile 19; Falls near mile 25; Berry Mountain near mile 30; and Woodmans near milepost 35. Milepost No. 40 is at the Federal mine. These camps afford bunkhouses and stables. A trip either way takes from two to three days according to the load and the condition of the road.

Much of the distance can also be covered with canoes. The Cascapedia is swift and contains a number of rapids, but canoes can be poled to Berry Mountain brook and up the Salmon and lake branches. Berry Mountain brook is too small for canoe travel. The lumber companies tow their supplies with horse teams up the Lake and Salmon branches. Scows can be taken in this manner as far as Loon lake on the Lake branch, and up to nearly the headwaters of the Salmon branch. In descending the Cascapedia all the rapids can be run by both scows and canoes.

HISTORY

Small deposits of zinc and lead ores were known at Grand Grève and other points on the coast in very early days, and attempts to mine the deposits were made. They proved, however, too small to be of commercial importance. More recently, reports of the discovery of gold, copper, lead, and zinc in the interior of Gaspe were circulated, but it was not until 1909 that any noteworthy discovery was made. In that year several prospectors found considerable quantities of lead ore on a hill near

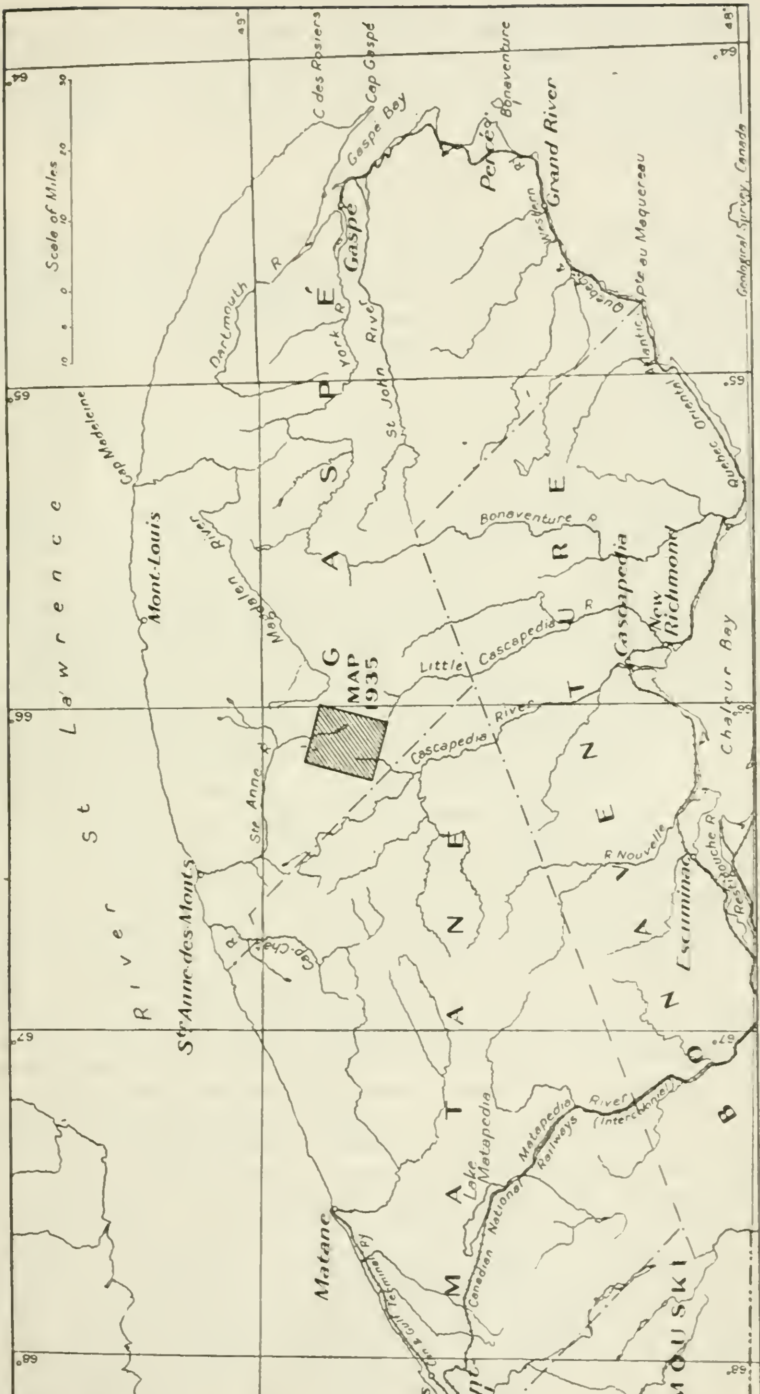

Figure 6. Index map showing location of map-area, Lemieux township, Gaspe county, Quebec.

Berry Mountain brook, on the site of the present Federal mine. In the following year James McKinley staked the hill and proceeded to search for the lode from which the fragments of lead ore had come. Since then many claims have been staked in the vicinity; those that have been Crown-granted are shown on the areal map. These claims are now held by two companies, the Federal Zinc and Lead Company and the North America Mining Company.

PREVIOUS WORK

In 1843 Sir William Logan explored the coast of Gaspe from Gaspe bay to Paspebiac, travelling along the shore with a canoe and one helper, walking most of the way, climbing cliffs, examining rocks, collecting fossils and rock and mineral specimens, and making a pace and compass traverse of the entire distance. He continued this work the following summer with a larger party. The north shore of Gaspe was followed from cap des Rosier to Cap-Chat river. This river was ascended in canoes and from its headwaters Logan struck through the woods and reached one of the tributaries of the Lake branch of the Cascapedia. Three canoes were built of spruce bark and in them the Cascapedia was descended to its mouth. A micrometer and compass survey was made of this traverse, several of the adjacent mountains were climbed, and a great deal of geological information was obtained. In the autumn of the same year Alexander Murray, who had accompanied Logan on this trip, proceeded eastward, and mapped Bonaventure river for 53 miles. Logan continued the examination of the Gaspe coast westward and ascended Matapedia river as far as lake Matapedia. In the following year Murray explored Matane, Ste. Anne, and St. John rivers. In 1857, J. Richardson ascended Magdalen river; in 1858 Robert Bell examined York and Dartmouth rivers. The results of these surveys were incorporated by Logan in his report of 1863 on the geology of Canada. The work of Logan and his assistants demonstrated the absence of payable coal in the peninsula and in a large way solved the major problems of stratigraphy and structure.

In the years 1882 and 1883 more geological work was carried out by R. W. Ells and A. P. Low. In 1882 Ells examined the coast and the rivers of Gaspe basin. In 1883 he mapped Bonaventure river and the Salmon and Lake branches of the Cascapedia. In 1883, Low ascended the Ste. Anne to lake Ste. Anne and mapped much of the region from the summits of mount Albert and Tabletop mountain. He also surveyed the Middle branch of Magdalen river. These traverses gave much new information concerning the interior of the peninsula. Later in the season Low made a complete traverse across the peninsula by ascending Ste. Anne river to lake Ste. Anne, making a portage of 3 miles from the south end of the lake to the west branch of Little Cascapedia river and descending that river to its mouth.

In 1902 and 1909 Ells examined parts of the peninsula in connexion with oil and oil-shale possibilities. His reports on both of these were unfavourable.

In 1908 J. M. Clarke, of the New York State Geological Survey, published the result of a number of years' work on the eastern coast of Gaspe. Clarke describes the stratigraphy and structure of these Silurian and early Devonian rocks and their immense fossil fauna. The great number of plates and the descriptions of the numerous species make this work a noteworthy contribution to Canadian palæontology.

During the summers of 1917 and 1918 Professor A. Mailhiot of L'École Polytechnique of Montreal, mapped an area of which the Federal mine is the central point. His report on the geology of this area was included in the annual reports for 1917 and 1918 of the "Mining Operations in the Province of Quebec".

Robert Chalmers made studies of the Pleistocene geology of Gaspe, and, more recently, Professor A. P. Coleman of the University of Toronto spent two seasons investigating the glacial history of the peninsula. The result of his investigations has recently been published as Bulletin 34 of the Geological Survey.

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GENERAL CHARACTER OF THE DISTRICT

TOPOGRAPHY

Regional Character. Gaspe peninsula comprises that part of the province of Quebec which lies south of St. Lawrence river and east of Matapedia river. It has a length in an east and west direction of about 150 miles and a greatest width of 85 miles. It is a region of Appalachian structure, consisting of Palæozoic rocks, whose structural trend is a curved line paralleling in a general way the north shore of the peninsula. Its northern coast rises abruptly from the St. Lawrence. In places steep cliffs 800 to 1,200 feet high terminate abruptly at the shore. At other places, as at the mouth of Marsouin river, the hills are only 200 to 400 feet in height, but, less than 6 miles inland, flat-topped ridges reach elevations of from 2,500 to 3,000 feet. The eastern end of the peninsula is marked by bays and cliffs. The cliffs are abrupt terminations of Appalachian folds which have been truncated by marine erosion. The southern coast along Chaleur bay shows an alternation of low rock cliffs, bays, bars, and beaches. This is the important agricultural part of the peninsula.

The interior of the peninsula is a plateau (Plate III A) dissected by deep valleys. The higher points lie along a central axis known as Shickshock mountains. Some of the elevations on this range rise to over 4,000 feet and form the highest land of eastern Canada. A good idea of what this high country looks like from one of the highest elevations can be got from the panorama made by A. P. Low from the summit of mount Albert[1]. The most striking feature is, probably, the mature character of the upland topography. Here and there projections rise above the general level, but on the whole there is a remarkable accordance of summit levels, and the sky-line is comparatively even in all directions. The various individual mountains also show this flat-topped character. Mount Albert, composed of serpentine, has a treeless, rock-strewn, flat surface on which Low in 1883 chained a base 3¼ miles long for triangulation purposes. Tabletop mountain shows a low, rolling topography developed on granite. Its surface is an undulating plateau dotted with numerous lakes and with a few peaks, some of which are 500 feet above the general summit level. Many of the other mountains show similar broad, flat tops. The country is folded, faulted, and intruded, and is made up of rocks of varying degrees of hardness and resistance to erosion, such as soft shales and limestones, hard, massive, volcanic rocks, granite, porphyries, serpentine, and metamorphic schists and gneisses. The truncation of a folded region of such diverse rocks to form a uniform plane like the present surface is to be explained only by base-levelling. Gaspe peninsula, therefore, is a region which must have been base-levelled and, later, uplifted and dissected.

The peninsula contains no rock formations younger than the Palæozoic and the age of this erosion surface can, therefore, only be inferred. The valleys (Plate III B) afford the best guide to the date of the present cycle. Throughout the peninsula they are in a stage of youth. Slopes are uniformly steep, in many places at the angle of repose of the rock debris. Slope angles of 35 degrees are common. Vertical cliffs are frequent where basalt forms the bedrock. A youthful topography, represented by these steep-sided valleys, is superimposed upon the old age topography of the upland

[1] Geol. Surv., Can. Rept. of Prog. 1882-83-84, pt. F.

surface. The valleys—with the probable exception of certain narrow canyons—are clearly preglacial, for many of them contain glacial deposits, but their youthful condition proves that they cannot be older than Pliocene. It is to be concluded, therefore, that the uplift of the region and cutting of the new valleys dates from Pliocene time.

The character of the uplift may to some extent be deduced from the present elevations of the old base-levelled surface. The point of greatest elevation is on Tabletop mountain whose summit is over 4,300 feet. Some of the other peaks exceed 4,200 feet, but the average elevation of the flatter part of the mountain is about 3,600 feet. Mount Albert has an elevation of 3,600 feet, mount Logan 3,700, and the other high mountains of the central belt run from 3,200 to 3,400 feet. The elevation of the plateau along the central axis of the peninsula may, therefore, be taken as about 3,400 feet, with the granite knobs of Tabletop mountain as monadnocks on the old erosion surface. At the Federal mine, and at Berry mountain, near the junction of Berry Mountain brook with Cascapedia river, the plateau has an elevation of about 1,900 feet. On the coast at Percé, mount Ste. Anne has an elevation of 1,200 feet. The plateau, therefore, has a decided slope to the sea. The uplift at the initiation of one of the cycles of erosion must, therefore, have been differential in character, with the maximum rise along the central axis of the peninsula.

The region stands high at present, but that in Pliocene time it must have stood higher is evident, for the valley of the St. Lawrence extends 200 feet below sea-level. Hence, although there has been uplift in post-glacial time—as is shown by raised beaches—it has not been sufficient to offset the depression that took place during the Pleistocene.

Relief of the Map-area. Mount Lyall, the highest point in the map-area, has an elevation of 3,100 feet. Its flat top shows a remnant of the old peneplain surface. Another remnant with an elevation of 3,000 feet lies southwest of lake Ste. Anne. Northeast of the lake the country reaches about the same elevation, but shows a greater degree of dissection. These higher parts consist of granite and volcanic rocks, the hardest rocks of the region. Northwest of lake Ste. Anne, the plateau country is developed in limestone and shale and reaches an elevation of 2,800 feet. The southern part of the map-area shows a decided slope southward to where Brandy brook and the various branches of Berry Mountain brook join Cascapedia river. The greatest difference of relief between adjacent points in the area is 1,700 feet, between the summit of mount Lyall and the surface of lake Ste. Anne. In the southwestern part of the sheet the average difference of elevation between the valley bottoms and the high, flat areas between the streams is about 600 feet.

Drainage. The map-area lies on the divide between three river systems: the Ste. Anne, which flows to the St. Lawrence, and the Grand Cascapedia and the Little Cascapedia which flow south to Chaleur bay. The area includes all the headwaters of the north branch of Berry Mountain brook. None of the streams is large enough for canoes, except the Ste. Anne at highwater. They all are swift. The average fall of the part of the Ste. Anne shown on the map-sheet is approximately 50 feet to the mile, that of Berry Mountain brook and Brandy brook about 150 feet to the mile, and the tributaries of these show a still steeper gradient.

Some of the valleys of the western part of the sheet are dry during the summer. Brandy brook itself was quite dry a short distance above where the trail from the Federal mine enters its valley. South of this point, however, there was a good volume of water which must have been supplied from underground.

The valleys have an average depth of about 600 feet and, as a rule, show steep slopes. The characteristic topography is flat interfluvial areas with abrupt descents to the streams. Valley slopes of 35 degrees are common. Steep cliffs are frequent where the bedrock is volcanic. Typical examples are seen along Brandy brook, and along the southwest side of lake Ste. Anne. West of Ste. Anne river is a very steep rise to the summit of a granite hogback. Small canyons occur locally, as in the

limestone in the northwestern part of the map-area, and in the volcanic rocks at the Narrows on Berry Mountain brook.

Lake Ste. Anne is a narrow body of water 3½ miles long which drains northward by Ste. Anne river to the St. Lawrence. It consists of three parts separated by narrows, caused by side streams which have built deltas out into the lake. The narrows between the north and middle parts of the lake is so shallow that even light canoes can be got through only with difficulty. The maximum depth in the northern expansion is 48 feet; the middle part has a depth of 18 feet; the southern expansion, where the shores rise steeply on either side, has a depth of 113 feet. Low states that at one point the lake is over 120 feet deep.

The present drainage of lake Ste. Anne is physiographically abnormal. The side streams which enter the lake, and the part of Ste. Anne river immediately below it, run in a general southeast-southwest direction, suggesting that the normal drainage of the valley occupied by the lake should be southward rather than to the north. Below Ste. Anne lake outcrops of basic volcanic rocks border Ste. Anne river, showing that in several places solid bedrock forms the bed of the stream. At one place 1¼ miles below lake Ste. Anne solid rock can be traced entirely across the stream channel, at an elevation of only 80 feet below the surface of lake Ste. Anne. The valley occupied by the lake—which has a depth of 120 feet—could not, therefore, have been cut by a stream flowing north along the present course.

The topographic map explains these abnormal features. South of lake Ste. Anne, the valley occupied by the lake continues in a direct line to Little Cascapedia river. The divide between the lake and the Little Cascapedia is very low—not more than 10 feet above the lake—and consists of loose material with no rock outcrops. The Little Cascapedia, where this valley joins it, is 130 feet below the level of lake Ste. Anne, or below the lowest part of the lake bottom. It is, therefore, apparent that lake Ste. Anne was once simply a valley occupied by one of the headwaters of Little Cascapedia river.

This diversion took place in Pleistocene time and its cause was a dam of ice and glacial debris from a cirque on the west side of the valley south of the present lake Ste. Anne. The waters of the lake were raised by this dam until an outlet was found over the divide to one of the tributaries of Ste. Anne river. This divide was, probably, between mount Albert and Tabletop mountain. Here the Ste. Anne now flows through a gorge with vertical walls 200 feet high, and at one point drops 60 feet. This gorge which in one place is less than 6 feet wide has most probably been cut since the diversion by the increased flow northward which the change in the direction of flow produced.

The topographic map (No. 1935) also shows that there were minor changes accompanying this major drainage change. The stream entering Ste. Anne river from the west, 2½ miles below Ste. Anne lake, cuts through a limestone canyon which has vertical walls. This stream drains three other streams that originally flowed southwest through a large valley with fairly mature slopes and now occupied by a very insignificant stream. Similarly the stream that is east of—and makes a sharp northwest turn to join—the Ste. Anne, at one time flowed along a course now occupied by four small lakes northeast of lake Ste. Anne.

GLACIATION

Coleman[1] showed that the high interior of Gaspe was not overridden by the Labrador ice-sheet. There are no glacial deposits above 2,500 feet. The tops of the higher mountains (Plate IV A) are rough and irregular in detail with minor irregularities and projections which could not have withstood a continental glacier; moreover, the loose rock debris consists of the same material as the solid bedrock. The region, however, was occupied by local glaciers which spread out chiefly to the south, north, and northeast.

[1] Geol. Surv., Can., Bull. 34.

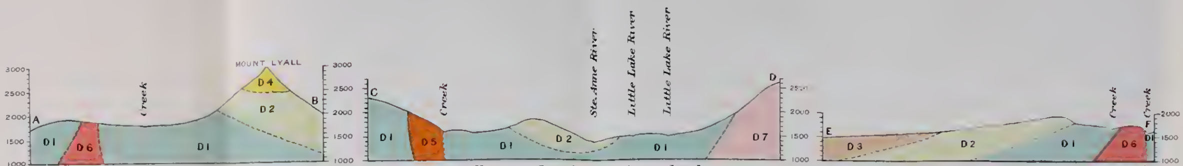
Canada
Department of Mines

HON CHARLES STEWART MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY

W.H. COLLINS, DIRECTOR

Issued 1922



Horizontal scale, 4000 feet to 1 inch.
Vertical scale, 2000 feet to 1 inch.
Structural sections along lines AB, CD, and EF

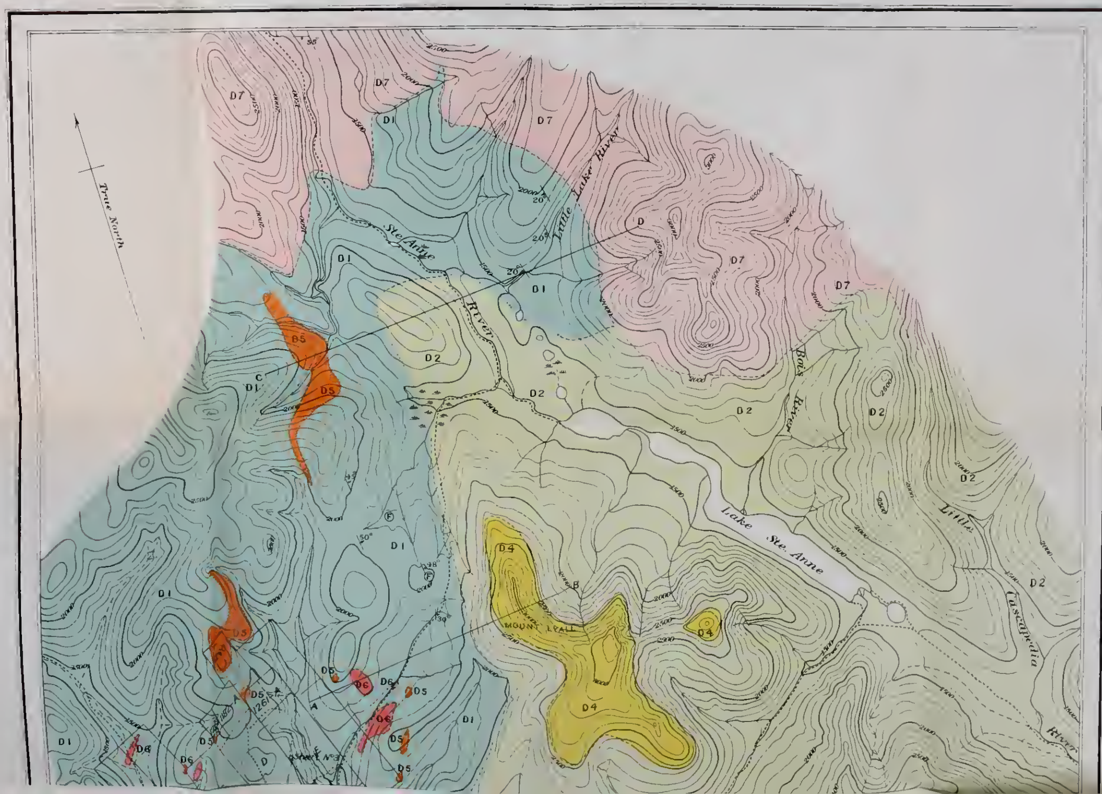
LEGEND

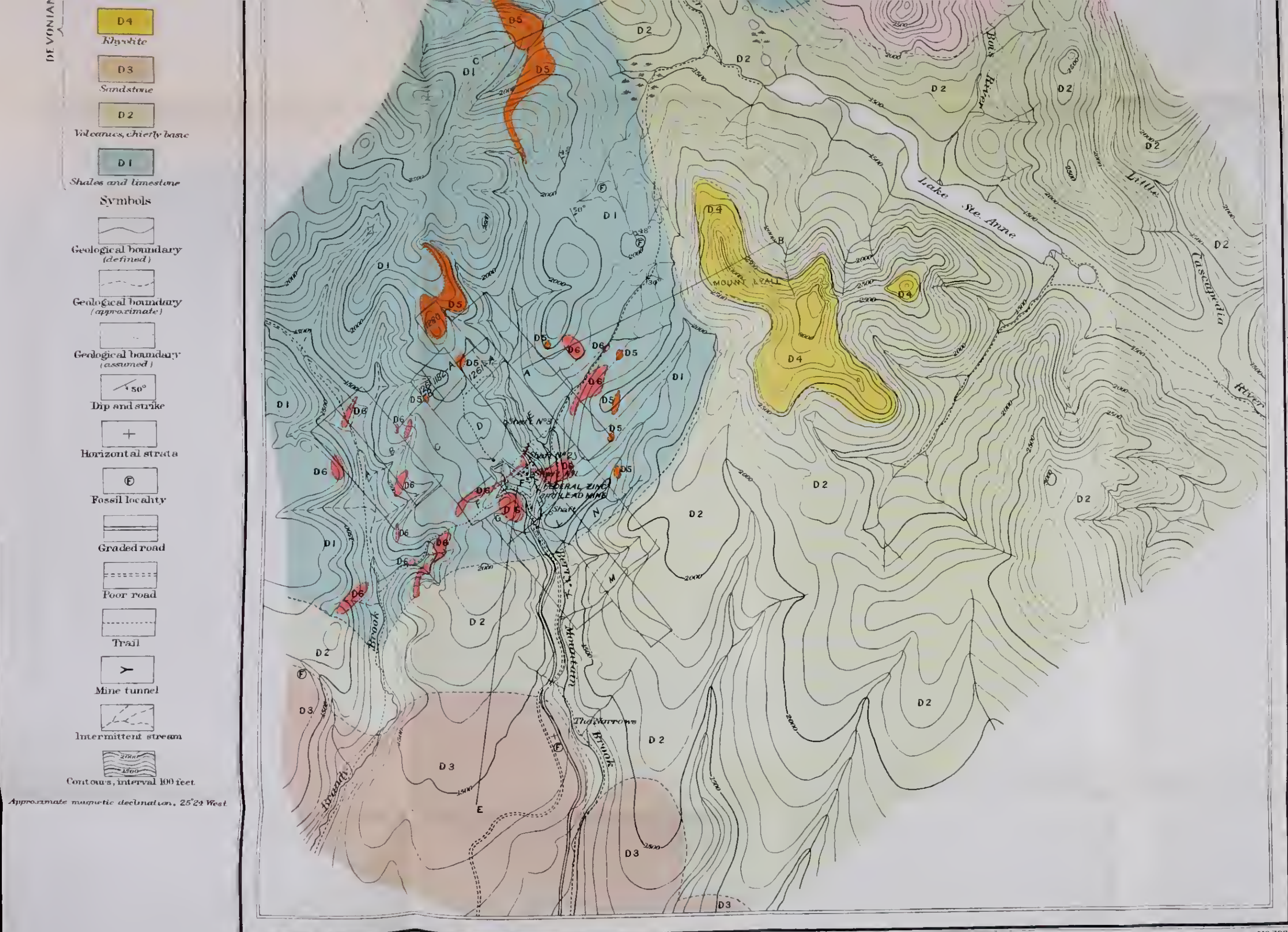
DEVONIAN

- D7 *Granite*
- D6 *Syenite*
- D5 *Porphyry*
- D4 *Rhyolite*
- D3 *Sandstone*
- D2 *Volcanics, chiefly basic*
- D1 *Shales and limestone*

Symbols

- Geological boundary (*defined*)
- Geological boundary (*approximate*)
- Geological boundary (*assumed*)
- Dip and strike 50°
- +





C.D. Senécal, Geographer and Chief Draughtsman.
J. J. Carr, Draughtsman.

Publication No 1935

PART OF LEMIEUX TOWNSHIP, GASPÉ COUNTY, QUEBEC.

Scale of feet

1,000 0 1,000 5,000 10,000

To accompany Report by F.J.Alcock, in Summary Report, Part D, 1921.

Geology and topography by F.J.Alcock, 1921

The map-area shows little sign of extensive glaciation. Over most of it the float, or rock debris, can be taken as an indication of the bedrock. The top of mount Lyall, and the mountain northeast of lake Ste. Anne, and the hogback in the northwest corner of the area are all covered with loose fragments of the same material as the bedrock. There are, however, a few foreign boulders among the rock debris on the hogback west of Ste. Anne river, the presence of which is not so readily explained. These may be residual.

The map-area does, however, show evidence of local glaciation. Along the west side of lake Ste. Anne a large well-developed double cirque forms two big amphitheatre-like hollows on the flank of mount Lyall. The walls in places are steep cliffs, and the top of mount Lyall is a mere knife-edge. Other smaller hollows representing less perfectly developed cirques occupy the valley of lake Ste. Anne.

Large erratics are met here and there as, for example, porphyry boulders on Federal hill, and a huge boulder weighing tons (apparently Precambrian quartzite) on the old road up the hill. These erratics were certainly transported by ice.

SUMMARY OF PHYSIOGRAPHIC HISTORY

Part at least of the physiographic history of Gaspe peninsula from Palæozoic time can be inferred even if a complete record must remain unknown. In Middle Devonian time the country was mountainous, probably rivalling the present Alps and Rockies. From then the history of the region has been one of denudation. How many cycles of erosion the region has passed through since the Devonian it is impossible to state, but sufficient denudation has taken place to uncover and incise a granite batholith. Probably in Mesozoic and Tertiary times the region was more than once reduced to base-level. Certainly in Tertiary time a very perfect peneplain existed in the peninsula with a low divide down the central axis. At that time the lofty mountains of the Devonian were represented only by low monadnocks. In Pliocene times there was uplift. The streams were rejuvenated and valley cutting began. The present elevation of Shickshock mountains, which are to a large extent mountains of denudation produced by the dissection of a plateau surface, is due to the Tertiary uplift.

In Pleistocene time the central part of Gaspe was occupied by local glaciers but was apparently not overridden by the continental ice-sheet. The local glaciers moved down the valleys, disorganized the drainage to a certain extent, and produced local cirques. The history since the disappearance of the ice has been one of erosion with local canyon cutting. Vertical movements in post-Glacial time are recorded by the presence of marine beaches. These show that there has been a rise along the north shore of the peninsula, but the absence on the Chaleur Bay side of any beach corresponding to the very marked Micmac beach on the north coast points to a recent sinking of the southern margin.

CLIMATE, AGRICULTURE, POPULATION AND INDUSTRIES, FORESTS, WATER-POWERS

Weather records have been kept at the Federal mine since August, 1918. The following table summarizes the more important data.

Monthly Mean Temperature

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1918	...	...	.....	.....	.....	.....	..	56	47	39	26	13
1919	8	17	22	33	44	59	60	52	47	33	24	
1920	....	...	25	34	45	52	57	60	48	41	15	13
1921	4	5	20	30	47	51	65	53	48	37	18	10

The lowest temperature recorded was −25 degrees, in January, 1919. January, 1921, saw a temperature of −21 degrees; February of the same year a temperature of −20 degrees. Both the mean and the lowest winter temperatures are higher than on the coast at Gaspe, Father Point, Cap-Chat, etc. The highest temperature recorded —87 degrees—was in August, 1920. July 1919 showed a temperature of 83 degrees; August, 1918, a temperature of 79 degrees.

The following table shows the monthly precipitation at the Federal mine, the snowfall being reckoned as 10 inches of snow to 1 inch of rain.

Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1918	......	......	......	......	......	......	......	2·82	5·58	2·13	2·28	1·85
1919	0·29	2·80	3·10	0·80	1·40	3·50	1·88	2·85	2·24	3·47	3·38	
1920	......	......	3·10	2·70	0·72	1·39	10·56	6·43	3·52	6·01	2·93	5·00
1921	3·30	1·20	5·41	0·19	1·25	2·20	2·87	7·14	7·65	4·71	3·55	4·05

The only year for which there is a complete record is 1921, when the total precipitation amounted to 43·52 inches. The incomplete record for 1920 shows over 42·36 inches. Eleven months of 1919 show a precipitation of 25·71 inches. The months in which the greatest amount of rain falls seem to be July, August, and September. Complete snowfall records are available for only two winters. The winter of 1918-19, November to April, showed a snowfall of 86·3 inches: the winter of 1920-21, December-March, had a snowfall of 122 inches.

About two acres of the hill on which the Federal mine buildings are located is planted with vegetables. Potatoes grow to a large size, yield abundantly, and are of excellent quality. The plateau region of the interior of Gaspe seems to be as well adapted for agricultural purposes as the littoral, once the difficulties of communication and clearing the land are overcome.

The population of Gaspe coast along Chaleur bay is engaged in agriculture, fishing, and lumbering. Settlements—both French and English speaking—extend up Cascapedia valley for 6 miles above Cascapedia station. There are no settlements in the interior of the peninsula.

When sinking operations were commenced there were no local men with experience in that class of work and miners were brought from Nova Scotia. Subsequently, however, local labour was employed and a number of men received a training in practical mining.

The country is for the most part well timbered, but the higher summits of the central axis are bare of trees. Other summits support a dense growth of dwarf spruce often not more than 5 feet high but so closely spaced and with their branches so intimately interlocked as to render progress most difficult. The top of mount Lyall is covered for most of its length with this type. Most of the hogback west of Ste. Anne river, and part of the ridge east of Ste. Anne lake, are bare. The valleys and lower interfluvial areas are, however, well wooded. The most abundant tree of the region is spruce, which includes the white, black, and red varieties. Balsam fir ranks next to spruce in importance. Of the deciduous trees, much the most important is white birch which grows to a large size and is particularly abundant on the flat tops of the interfluves. In lower Cascapedia valley, maple, cedar, and black birch are also found.

Lumbering and the preparation of pulpwood form one of the important industries of the peninsula, but in the area under discussion no lumbering operations have been carried on except for the purposes of mining development.

The streams of the area are small. Should waterpower be required for electrical smelting or for other purposes, it could be brought from the Grand Cascapedia where there is throughout the year a sufficient volume.

GENERAL GEOLOGY

GEOLOGY OF THE PENINSULA

The following is a generalized summary of the rock succession in Gaspe peninsula:

Devono-Carboniferous?	Bonaventure series
	Unconformity
Middle Devonian	Gaspe sandstone
	Unconformity
Lower Devonian	Gaspe limestones
Silurian	Mount Joli massive
	Black Capes section, etc.
	Unconformity
Ordovician	Quebec group
	Unconformity
Precambrian	Metamorphosed sediments and igneous rocks.

Palæozoic igneous rocks: acid and basic lava flows; acid and basic sheets and dykes; peridotites, largely serpentinized; deep-seated acid intrusives.

Precambrian Rocks

The rocks grouped under this head include a series of highly metamorphosed sediments and eruptives. They consist of hornblende and chlorite schists, chloritic slates, grey gneisses often garnetiferous, mica schists, grey quartzites, impure limestone locally interstratified with bands of serpentine, altered limestone-conglomerate, massive chloritic rocks, and epidote-bearing rocks consisting chiefly of quartz and epidote. The age of this series of rocks is not definitely known to be Precambrian, but they are so much more highly metamorphosed than even the oldest of the Palæozoic rocks that it is highly probable that they are pre-Palæozoic.

Quebec Group

The rocks included under the term Quebec group are considered to range in age from Cambrian to late Ordovician. They consist of red, green, and grey shales, black graptolitic shales, grey and green sandstones, grey limestone and limestone-conglomerate. These rocks form a broad band along the St. Lawrence River side of Gaspe peninsula. Another area occurs on the southeast coast in the vicinity of cape Macquereau and Grand Pabos. They were folded locally and suffered erosion before the deposition of the Gaspe limestones.

Silurian

Just how much Silurian is exposed in Gaspe is one of the unsettled problems in connexion with the geology of the peninsula. Considerable areas of the interior have been mapped as Silurian, but, as will be shown later, it is probable that most of these are really Lower Devonian. Undoubted Silurian rocks, however, do occur. At Percé, the Mount Joli massif is Silurian. At Black Capes, also, there is a section showing a thickness of over 7,000 feet of Silurian rocks, the thickest Silurian section in America. The lower strata of this section contain abundant Niagara fossils; the upper part shows evidence of having been deposited—partly at least—under subaerial conditions, and is probably of delta origin.

Gaspe Limestones

The Gaspe limestones of Logan were classed by him as Silurian. Later work, however, has shown them to be Lower Devonian. Clark divides them into three divi-

sions based on lithological and faunal characteristics. The lowest is the St. Alban beds consisting of calcareous shales; conformably above these are the Bon Ami beds consisting of magnesian limestones and containing but few fossils. The upper member, also conformable to the rest, is the Grand Grève limestone; it contains an abundant fossil fauna of Helderberg-Oriskany types. Logan estimated the thickness of these rocks at 2,000 feet, of which the Grand Grève beds include 600 feet.

Gaspe Sandstone

The Gaspe sandstone covers wide areas of the interior. In fact the areas coloured as Devonian on areal maps of the peninsula really mean this series, and the areas coloured Silurian are largely at least Lower Devonian. The series was stated by Logan to have a thickness of 7,036 feet. It is very homogeneous, consisting of grey, drab, and reddish sandstones with some shaly and conglomeratic beds. Some of the lower beds contain a marine fauna of apparent Hamilton age. Certain horizons contain great numbers of fossil plants, chiefly Psilophyton species. Near the middle of the section there is a bed of coal from 1 to 3 inches in thickness. The Gaspe sandstones are folded up with the Gaspe limestones on the coast. There is apparently, however, a slight angular unconformity between the two series. The fact that in the interior of the peninsula the sandstone series is as a rule less deformed than the limestones, suggests a period of movement between the deposition of the two series. Flows and intrusions of igneous rocks are associated with the sandstones.

Bonaventure Series

Bordering Chaleur bay an horizontally-lying formation known as the Bonaventure series rests unconformably on the older Palæozoic rocks. It is coarsely conglomeratic and its deep red colour makes it a very conspicuous feature of the Gaspe coast. Mount Ste. Anne at Percé and Bonaventure island are composed of this formation. It contains numerous fossiliferous boulders of Gaspe limestones, but its matrix has not been found to contain any fossils from which the age of the series may be definitely determined. It is certainly later than the period of Devonian deformation, and has been classed by some authors as Upper Devonian, by others as Lower Carboniferous. The series has a thickness of at least 1,200 feet.

Igneous Rocks

Flows and dykes of basic composition are numerous in the Gaspe sandstone series. In the interior of the peninsula there are also acid flows, sheets, and dykes, deep-seated acid intrusives represented by dykes and stocks of syenite, and the granite batholith of Tabletop mountain. Three areas of serpentine, also, occur. The largest is the Mount Albert mass, which is 12 miles long and has a greatest width of $3\frac{1}{2}$ miles. A second, forming South mountain, lies about 12 miles west of mount Albert. It has a length in an east and west direction of about $2\frac{1}{2}$ miles and a width of $\frac{3}{4}$ mile. A third and smaller area is found on Dartmouth river. These rocks are apparently intrusive into the sedimentary rocks of the region and hence are post-Lower Devonian in age.

GEOLOGY OF THE MAP-AREA

The consolidated rocks of the map-area consist of sediments, volcanics, and intrusive rocks of both hypabyssal and deep-seated varieties. The following is the succession:

Porphyry, granite, syenite
Intrusive contact
Gaspe sandstone
Basic and acid volcanics
Shales and limestones

Shales

The oldest rocks in the vicinity of the Federal mine are sediments, which consist largely of shales exposed in several of the stream beds, in cuttings for the mine roads, in prospect pits, and, best of all, in the underground workings. The shales vary from grey and greenish to black; weathered fragments are commonly light grey. They frequently show a distinct colour banding, each band differently tinted. The beds are mostly thin, varying from a fraction to an inch to over 6 inches. Small amounts of sandy material are interbanded with the argillaceous beds. Limestone beds and calcareous shale horizons are numerous. In places the limestone associated with the shales is black and contains abundant crinoid stems. Near the mine the strike of the sediments varies considerably but has a general east and west direction, with a dip to the south of from 30 to 70 degrees. The shales have been broken up by earth movements. In places breccias composed of angular fragments of all sizes and shapes are formed; in other places the beds are finely jointed and, locally, even a cleavage is developed across the bedding planes.

Limestones

As already mentioned limestone is found interbedded with the shales at the Federal mine. This variety is massive, dark grey to black, and weathers brownish. From the hill on which the mine bunk-house is built the following fossils were collected:

Crinoid stems
Cœlospira concava
Meristella cf. *champlani*
Leptostrophia blainvilli

From a boulder in the brook at the foot of the hill *Fenestella* and crinoid stems were collected.

The sediments in the northern part of the map-area are dominantly limestones, and are well exposed on nearly all the streams. In places vertical cliffs 50 to 100 feet high are to be seen. The rock consists of grey limestone, thin to thick bedded, and locally fossiliferous.

An outcrop west of the Ste. Anne trail supplied the following fossils:

Atrypa reticularis
Spirifer murchisoni
" *gaspensis*
" *arenosus*
Orthothetes (Schuchertella) becraftensis
Actinopteria sp.
Lentaculites elongatus
Phacops logani

Kindle reports that this fauna represents an early Devonian horizon. Probably all the forms collected are from the Bon Ami and the Grand Grève limestones, subdivisions of Logan's Gaspe Limestone series.

Limestone outcrops on the streams that join Ste. Anne river from the southeast below lake Ste. Anne. The beds average 2 or 3 inches in thickness. There is only a little shale but a great deal of sandy rock, and at one place sandstone is abundantly interbedded with the limestone. A fragmental rock, also, of apparently pyroclastic origin, was found at a point about 3,000 feet east of the Ste. Anne.

Gaspe Sandstone

The southwestern part of the map-sheet is covered by a greywacke formation which is equivalent to what on the coast has been termed the Gaspe sandstone. In this area it rests on a thick mass of basic volcanic rocks which will be described subsequently. The series is coarse, in places conglomeratic. It varies from green

and drab to reddish. It apparently consists partly at least of weathered volcanic material. It is coarsely bedded and locally crossbedded. Some of the finer layers show ripple-marking. A few fossils collected from the area proved to be brachiopods and lamellibranchs. The lower horizons of this series on York river contain an abundant fauna which has been described by Clark. Kindle, reporting on the writer's collection, says the fossils represent a Hamilton horizon but include a few Oriskany forms which are apparently survivals of an early Devonian sea and came from another region. In an outcrop on the Federal mine road, 2½ miles south of the mine, some fossil plant remains were collected on which W. A. Bell reports, "The plant material is preserved poorly as flattened carbonized residues, and imprints of dichotomously branching stems. They clearly are referable to the Devonian group of Psilophyton Dawson. The stems are smooth or irregularly furrowed, but there are imprints that are definitely costate. No spinous appendages are present as in *P. princeps* var. *ornatum* Dawson, and the resemblances to the stems from Campbellton, N.B., figured by White, are quite close. The latter were included by Dawson in his *Psilophyton princeps*. On the other hand the present stems may be identical with *Psilophyton robustius* Dawson, the poor preservation and the absence of fructifications prohibiting further comparisons."

The beds along the mine road lie horizontally in striking contrast to the folded, faulted, and breciated shales and limestones at the mine. In one of the streams entering Brandy brook there are also outcrops of arkose which lies flat. Here, moreover, are beds containing shale pebbles up to an inch in diameter, mostly rounded and flat and apparently of the same character as the shales found in place at the Federal mine. There appears to be no doubt, therefore, that the Gaspe sandstone of the map-area was deposited later than much at least of the deformation which disturbed the rocks of the region, and that there was also a period of erosion as well as deformation between the deposition of the shales and limestones and deposition of the clastic rocks. The intimate association of the fragmental beds with the flows and dykes of basic rocks shows also that the period in which they were laid down was also one of igneous activity.

As to the origin of the Gaspe sandstone, its invertebrate fossils are marine forms, but are limited to a few horizons and are abundant only in certain beds towards the base of the series. Plant remains are found throughout a much wider stratigraphic rangs and the forms are Psilophyton, which are now known to be terrestrial plants. The series, therefore, was, apparently, deposited largely under terrestrial rather than under marine conditions. The character of the sediments leads to the same conclusion. The series is dominantly clastic. The beds consist of sandstone which is commonly arkosic and often conglomeratic. One bed of conglomerate described by Logan has a thickness of 156 feet. There are only subordinate amounts of shale and no limestone. The series is probably over 5,000 feet, a fact which in conjunction with the wide areal extent of the series points to a continental origin. The formation is crossbedded and ripple-marked. Its reddish colour suggests deposition under conditions in which oxidation kept pace with accumulation, i.e. subaerial rather than marine. It is probable, therefore, that the series was deposited as deltas and along river flood-plains rather than along a coast or in arms of a sea. At times marine floods may have extended up the valleys.

Part of this clastic material was undoubtedly derived from local volcanic rocks; its lithological character and great thickness, however, suggest that much of it was derived from some granitic terrane which was undergoing erosion. The pre-Devonian rocks of Gaspe, including even the Precambrian varieties, are not such as would give an arkosic type of sediment. The granite batholith of the interior of the peninsula or that of New Brunswick has not as yet been unroofed. It seems necessary to conclude, therefore, that much of the material from which the series was built up was derived from the Precambrian granite country north of the St. Lawrence. If this conclusion be correct, it follows that in pre-Gaspe time the drainage across the

Gaspe region must have been in a general south or southeast direction. A detailed mapping of the area throughout the entire peninsula with fuller information as to lithology and thicknesses might perhaps determine whether this theory of deposition along north and south lines is correct.

Basic Volcanics

Basic volcanic rocks cover about 60 per cent of the map-area. They overlie the shales and limestones and are in turn overlain by the Gaspe sandstone of the southwestern part of the sheet. Good exposures of these rocks are numerous. They outcrop along the new mine road and the old road along Berry Mountain brook. At what is known as the Narrows, Berry Mountain brook flows through a narrow gorge of these rocks and almost vertical cliffs border Brandy brook at one point. At several places low cliffs border Ste. Anne river. These rocks are the hardest of the region and almost all the abrupt slopes, except a few limestone cliffs, are formed of them. The ridge southwest of lake Ste. Anne, whose summit can just be seen from the Federal mine, consists entirely of these basic rocks.

The rocks present considerable variations. Some are dense and black; others are distinctly porphyritic with laths of feldspar in a dense matrix. Amygdaloidal varieties are seen in a number of localities. Good exposures of this type are to be found on the old mine road and in the Narrows of Berry Mountain brook. Some of the amygdaloidal varieties are also porphyritic. On the graded road about 2 miles south of the Federal mine, a dense black amygdaloidal lava contains numerous phenocrysts of white plagioclase. Many of the amygdules which consist largely of calcite have a greenish border composed of the chlorite, delessite. They are commonly flattened oval masses and some of them reach a length of over one inch. Some of the smaller amygdules are completely filled with delessite. Quartz also serves as an amygdule filling, but in minor amounts. One amygdule 2 inches in diameter was found lined with agate layers and with the interior filled with quartz crystals pointing towards the centre. At one place near the mine road a large erratic composed of basic rock shows good ellipsoidal structure. No similar structure was seen in place, although the rock is evidently part of this same series and of local origin. Some of the flow rocks weather reddish-brown.

Thin sections of the basic rocks show a considerable range of types. The steep slopes opposite the Federal mine consist of a dark, dense rock with small phenocrysts of feldspar. Some of these plagioclase phenocrysts are clear; others contain a great amount of iron ore inclusions. The main mass of the rock consists of augite crystals penetrated in all directions by laths of labradorite. A little olivine is present, partly altered to serpentine. Considerable amounts of chlorite are also present; some of it is dark green with sharp outlines and is apparently primary. Iron ore is present in considerable amounts. It is largely magnetite but a little hematite is also seen. This is the only section studied in which olivine was found to be present. A number of other sections show a typical ophitic texture with no phenocrysts present and with almost all the augite altered to a pale green chlorite. A section from the black volcanic rock at the Narrows shows a similar type, but in addition some small shreds of reddish-brown biotite.

The basic rocks are locally mineralized. In the amygdaloidal variety at the narrows of Berry Mountain brook cubes of galena are found in places in the calcite amygdules. At another place on the mine road small veins of calcite containing galena were found in basic flow rocks.

Acid Volcanics

Acid volcanic rocks occur at a number of places in the map-area. In places they are associated with basic flows and are undoubtedly part of the same period of volcanic activity. In most places it was not found possible to separate the two types

owing to lack of exposures and to local resemblances of types. For example, certain dense black rocks on close examination are found to have phenocrysts of quartz and under the microscope are found to be quartz-porphyries. One area, however, of a reddish acid volcanic on the top of mount Lyall is so sharply marked off from the underlying basic volcanics that it was mapped separately. On the lower slopes of the same mountain thin flows of grey volcanic rock were found associated with the basic rocks but in exposures too small to be represented on the map.

The acid volcanic on the summit of mount Lyall is a dense yellow to reddish rock containing small phenocrysts of quartz and pink feldspar and is to be classed as a rhyolite. In places it shows good sheet jointing. In thin section the phenocrysts are seen to consist of quartz and orthoclase. Some of the quartz crystals show sharp crystal outlines, others show corroded borders. The feldspar phenocrysts are commonly long, tabular crystals of orthoclase. The groundmass in some sections is a brownish glass, in others it is cryptocrystalline.

The reddish rhyolite that forms the summit of mount Lyall is underlaid by dark-coloured volcanics, associated with which are some acid flow rocks. These acid rocks outcrop at an elevation of 2,100 feet in the beds of streams which flow down the cirque of mount Lyall. In hand specimen the rock is light grey to pinkish. In places it shows banded lines of flow. Other specimens contain small, round or irregularly-shaped, masses of chalcedony. Still others contain vugs filled with agates. In the shallow bay immediately southwest of the second narrows on lake Ste. Anne many agate-filled vugs were collected, some of them over 4 inches in diameter.

In thin section the groundmass of this variety is seen to be cryptocrystalline, and probably represents a devitrified glass. Chalcedony is abundantly present as brownish radiating fibres. Small agate-filled cavities are also to be seen in the section. One of these extends across the section as a long, narrow vein. Small amounts of iron ore are also present. The rock is an acid flow which has been acted upon by siliceous solutions.

Acid Hypabyssal Rocks

Porphyritic rocks of many varieties are found throughout the map-area. Many of them occur as dykes; others of greater size are apparently sills or stocks. In most cases there are not enough outcrops to determine the exact boundaries of these masses or their exact relationship to the intruded rocks. Some of them approach in appearance the rock which forms the summit of mount Lyall and which has been described as an extrusive. They are apparently of the same general composition as this rock and of similar composition also to some of the deep-seated acid rocks which will be described later. They were intruded near the earth's surface, in some places following, in other places cutting across, the structural planes of the intruded rocks.

One of the largest areas forms a hill over 2,300 feet high, about 1½ miles north of the Federal mine. The rock is a dense reddish variety showing phenocrysts of quartz and feldspar. In thin section some of the quartz phenocrysts show crystal outlines, others slightly corroded borders. The feldspar is orthoclase. Pale green hornblende, secondary after either hornblende or biotite, is present and also some iron ore. The groundmass of the rock is microcrystalline consisting of quartz and orthoclase. Numerous dykes throughout the area show similar features. In some the phenocrysts visible to the naked eye consist entirely of pink orthoclase.

Basic Hypabyssal Rocks

As already mentioned, many of the basic rocks show a distinct porphyritic texture. In many cases these types are known to be extrusives because of their amygdaloidal structure and field relationships: some may be hypabyssal intrusives. Many of the sections studied show a coarse ophitic texture characteristic of diabase. Diabase dykes that cut the Devonian and older rocks are known in many places throughout Gaspe peninsula and some of the basic rocks have, probably, intrusive relationships to the older rocks.

Plutonic Rocks: Granite

The northeastern part of the map-area is underlain by the southwestern part of a granite batholith which forms Tabletop mountain. This batholith, as outlined on the older geological maps of the peninsula, has a length in a north and south direction of 17 miles and an average width of 4 miles. It forms the highest land of Gaspe peninsula and is rather striking in the fact that its longer axis cuts directly across the structure of the sedimentary rocks.

The part of the batholith contained in the map-area is intrusive towards the limestone and the volcanic rocks. The rock is even grained, but locally shows a tendency to porphyritic texture. It varies from grey to reddish and becomes progressively coarser-grained as one progresses from the contact with the intruded rocks towards the interior of the intrusive.

A good exposure of the contact phase of the granite is exposed on Ste. Anne river just below where the river trail crosses to the east side of the stream. The rock is dense and massive, and light grey, resembling limestone in appearance, but holding small crystals of feldspar. In thin section the rock is seen to be distinctly porphyritic. The phenocrysts consist chiefly of orthoclase, but some oligoclase is also present. Some of the orthoclases show sharp crystal boundaries, and Carlsbad twinning is present in many. The feldspars are all partly altered. One large phenocryst of quartz with corroded borders is present in the section. Some pale green chlorite represents the original ferromagnesian mineral, probably hornblende. The section also shows small irregular masses of carbonate which may represent incompletely digested fragments of the intruded rock. The groundmass of the rock is microcrystalline and consists of quartz and orthoclase. Small amounts of iron ore are present.

The hogback west of Ste. Anne river in the northern part of the map-area shows a slightly coarser-grained phase of the same rock. In places it is greyish, in places distinctly pink. Small individual crystals and cleavage surfaces of feldspar, minor amounts of quartz, and small dark specks representing the ferromagnesian constituents can be distinguished in hand-specimens. In thin section the rock is seen to consist of feldspar and quartz crystals in a matrix composed of smaller crystals of the same minerals. The feldspars, which are all more or less altered, consist dominantly of orthoclase but with a little acid plagioclase. Quartz, though fairly abundant as large crystals of irregular outline and as smaller fragments in the matrix, is much less common than the feldspar. The ferromagnesian constituent is hornblende, which is largely altered to chlorite. The rock is on the border-line between granite and syenite.

On the ridge northeast of lake Ste. Anne the intrusive shows a gradual coarsening of grain from the contact with the limestone and volcanics towards the interior of the mass. Away from the contact it has a typical granitic texture. The most abundant mineral is feldspar, comprising orthoclase and albite in about equal amounts. Graphic intergrowths of orthoclase and quartz are also abundant. Quartz is present, but is much less abundant than the feldspar. Hornblende, also, largely altered to chlorite, is present. Iron is an accessory constituent. The texture is fairly even grained and typically granitic.

This batholith appears to have produced but little contact metamorphic effects. No actual contacts between the intruded and the intrusive rocks were observed, but the intruded rocks near the granite intrusions have not been greatly altered.

Syenite

Syenite intrusions occur at a number of places in the neighbourhood of the staked claims. Most of them are linear bodies or dykes; others are of the nature of small stocks cutting the shales and limestones.

In hand specimen the rock is as a rule reddish, due to the presence of orthoclase feldspar. It is fairly coarse grained; individual feldspar crystals reach a length

of over half an inch. At one place in the dyke immediately northwest of the Federal mine, Carlsbad twins of orthoclase, half an inch in length, can be picked out of the weathered rock. Many of the feldspar crystals are long and lath-shaped. There is no quartz in the sections studied, but considerable quantities of dark ferromagnesian minerals are present.

All the sections of these rocks proved to be badly altered. The freshest was from a specimen collected from the small stock about half a mile southwest of the Federal mine. This is a coarse-grained rock with granitic texture. The feldspar is largely orthoclase. Some striated feldspar of the composition of oligoclase is also fairly abundant. The hornblende is almost all altered to pale green chlorite. One crystal of colourless augite is also present in the section. Both magnetite and pyrite are abundant as accessory minerals.

Serpentine

To the north of the map-area lies a large mass of serpentine through which the south branch of Ste. Anne river has cut a channel. A reconnaissance trip was made to the summit of mount Albert to see this belt of rocks. On the summit the rock is locally banded, but elsewhere it is massive. It weathers to a buff colour, and the weathered surfaces in places show a coarse mesh structure. Freshly-broken surfaces are dark green to almost black, and masses of green olivine can commonly be seen. In places the rock has a coarse fibrous structure due to the presence of picrolite. A little chromite is associated with it, but, so far as has been observed, only in small, widely-scattered pockets.

Sections of specimens collected at elevations of 2,450 feet, 2,700 feet, and 3,200 feet were studied. The first two consist almost entirely of serpentine which has resulted from the alteration of olivine. Only very small amounts of the olivine have escaped serpentinization. A little chromite is present. The section of the specimen from the top of mount Albert shows in addition to the serpentinized olivine considerable quantities of a pale orthorhombic pyroxene, which is probably enstatite. The enstatite is altered along irregular fractures to bastite. This rock corresponds to the harzburgite of Rosenbusch.

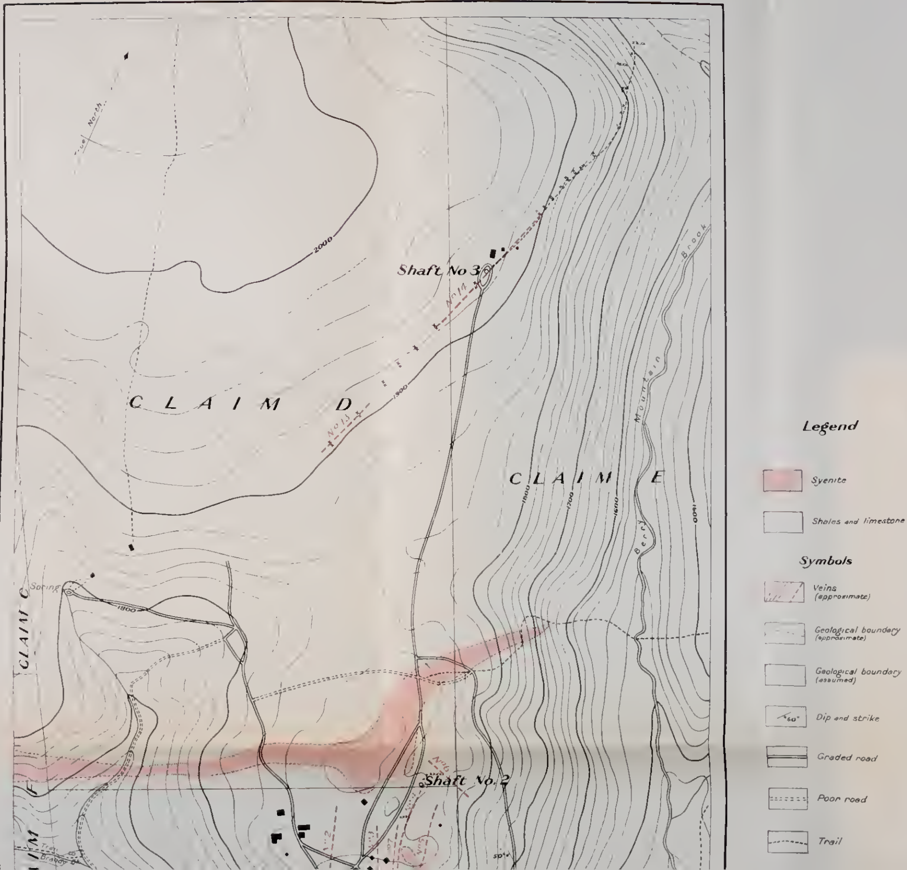
Summary of the Igneous Rocks

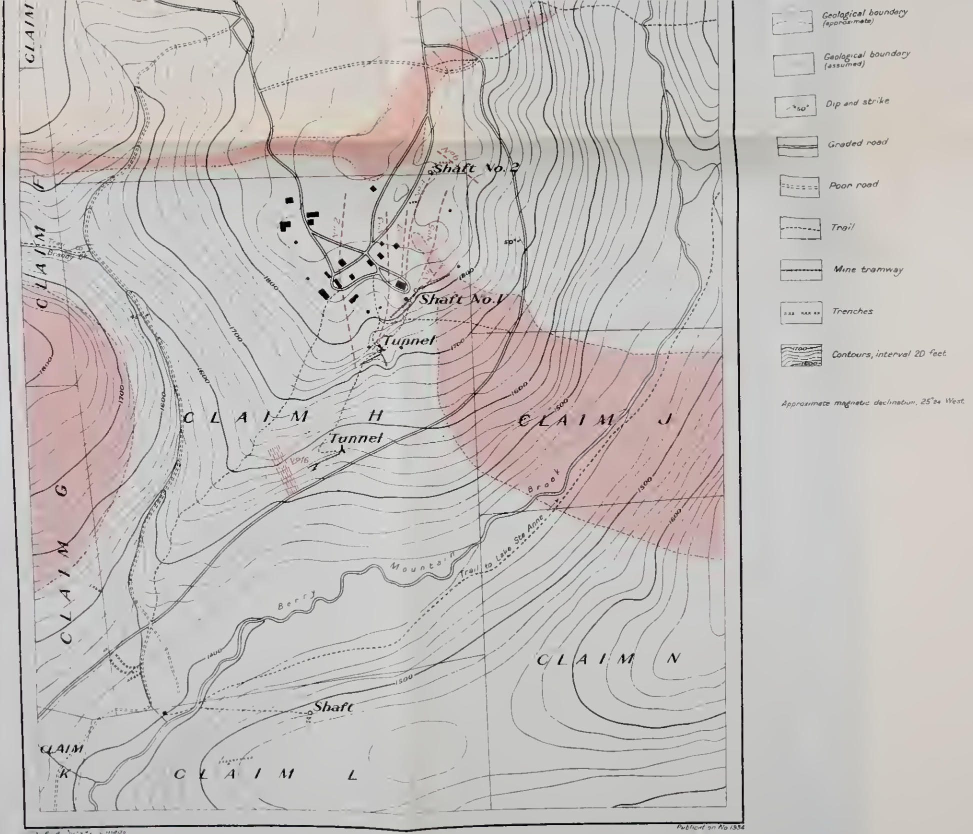
The igneous rocks of the area are younger than the shales and limestones and hence are post-Lower Devonian. The Gaspe sandstone was laid down in a period of igneous activity. In the area mapped the sandstone overlies thick flows of basic eruptives. In other places it is intruded by dykes of diabase and porphyry. It is probable, therefore, that most of the igneous rocks belong to the Middle Devonian, a period in which both acid and basic rocks were intruded, some at depth, others near the surface, and still others were poured out of craters and fissures and were distributed over the country. Whether all the rocks from the granite to the periodotites were derived from a common parent magma is not known.

STRUCTURE

Gaspe peninsula is a region of typical Appalachian structure, the rocks being thrown into folds and broken by both normal and thrust faults. The structural trend is mainly east and west forming a broad curve which roughly parallels the north shore of the peninsula.

The cross-sections on the map of Lemieux township (No. 1935) show the structure of the area. The Gaspe sandstone and the volcanic rocks have been but little disturbed. The Lower Devonian shales and limestones have, however, been folded and faulted. In the northern part of the area these rocks form a syncline whose axis trends in a general north and south direction. Intrusion of the Tabletop batholith is obviously responsible for this local structure being different from the regional structure of the peninsula.


North
2000
1800
Shaft No 3
No 14
No 13
CLAIM D
CLAIM E
CLAIM C
Spring
1800
1700
1600
1400
Berry Mountain Brook
Shaft No. 2
Legend
Syenite
Shales and limestone
Symbols
Veins (approximate)
Geological boundary (approximate)
Geological boundary (assumed)
Dip and strike
Graded road
Poor road
Trail



Federal zinc and lead mine, and vicinity,
Lemieux Township, Gaspé County, Quebec.

Scale of Feet

Geology and topography by F J Alcock 1921

ECONOMIC GEOLOGY

LEAD-ZINC

Crown-granted mineral claims of the area (Map 1935) are held by two companies, the Federal Zinc and Lead Company and the North America Mining Company. Almost all the exploration and development work has been carried out by the former company. The president of the Federal company is Mr. T. O. Lyall; the vice-president and general manager is Mr. J. C. Beidelman; the company's headquarters are at 285 Beaver Hall Hill, Montreal.

Character of the Deposits. The deposits are in Devonian shales and limestones intruded by porphyry and syenite. The sediments are folded, faulted, jointed, and brecciated. There has also been movement after the period of mineralization.

The country is covered by a heavy overburden and in consequence outcrops are few. The presence of ore is usually detected by finding pieces of galena in the float. These sometimes form large rounded masses, weathered brownish; as a rule they have not travelled far, and by trenching uphill from such float, vein outcrops can usually be uncovered. In other cases actual outcrops of veins are exposed. Most of these outcrops consist of chambered quartz from which the zinc blende, and often also the galena, has been leached. The quartz is white or perhaps stained brownish; the amethystine variety, common underground, is usually bleached white in the surface exposures.

In the form the deposits are veins, and like most veins they pinch and swell. In some places they show sharp contacts with the enclosing rock, in other places there is a brecciated zone in which there is a more or less gradual transition from massive vein material to barren country rock. In places the latter type becomes a stockworks. Horses of country rock of various sizes and shapes are found in the veins and have sharply-defined borders and angles, showing that the solution which deposited the vein material did not affect the shales.

The dip of the veins is for the most part over 70 degrees. The larger veins run in a general northeast direction, cutting across the strike of the sediments. They apparently follow fault and brecciation planes, with mineralization to a lesser extent along joint planes. In addition there has been movement later than the mineralization. One fault parallels the west wall of the Federal vein, and 180 feet north of the north crosscut, the same vein is cut off on the 100-foot level by another fault.

Mineralogy of Deposits. The minerals of the veins are sphalerite and galena in a gangue of quartz and carbonate. Pyrite, marcasite, and chalcopyrite are present in very minor amounts. The sphalerite is for the most part light yellow, varying locally, however, to a reddish brown, and is almost free from iron. It compares favourably with the best Missouri blende.

An analysis (made by J. T. Donald and Company, Montreal, for the Federal Zinc and Lead Company) of a sample of ore gave the following results:

	Per cent
Insoluble and silica	0·35
Iron oxide	0·82
Alumina	0·10
Sulphur	32·46
Zinc	66·00
Lead	Traces
Lime	None detected
Magnesia	None detected
Cadmium	None detected

In the surface exposures and to a certain extent in the upper parts of the veins the sphalerite has been leached out by surface waters, but the leaching has affected only slightly the amount of zinc blende originally present. Some of the surface specimens have a white coating which consists of an intimate mixture of zinc silicate

or calamine, zinc carbonate or smithsonite, and zinc hydrated carbonate or hydrozincite. A soft, white kaolin mineral is also found on the 100-foot level, and even on the 250-foot level, but only in small amounts.

On the 250-foot level a greenish-yellow mineral is associated with the zinc ore both in the veins and in the breccia. This mineral was found to be an hydrated silicate of aluminum carrying a smaller quantity of magnesium. The ratios of silica to aluminum and magnesium are as follows: for 12 Si there are 8 Al and 1 Mg; the water ratio was not determined. The mineral when examined under the microscope was seen to consist of low birefringent fibres. The mean index of refraction is 1·566. It does not possess physical and chemical characters sufficiently well defined to place it in the mineralogical nomenclature. It is certainly a mineral of the kaolinite group carrying in addition a small quantity of magnesia.

The galena is less abundant than the sphalerite, but there are places where it occurs in large masses. Being less soluble than the sphalerite, it persists in the upper parts of the vein; and in some of the outcrops it occurs in the quartz, often with a reddish brown coating of iron oxide. The cleavage surfaces range from minute areas to surfaces over 2 inches across. In one vug lined with small crystals of dolomite an excellent galena crystal showing cube faces truncated by octahedron corners was found. Some of the larger masses of galena show strain effects, produced by movement after the periods of mineralization.

The chief gangue mineral is quartz, both white and amethystine. In places the quartz is definitely banded, and frequently there is good comb structure. At one place in the Federal vein there are six of the parallel fillings which show that at least six times the vein was closed and reopened along the wall. The banded veins which show this comb structure in the centre almost always consist of the amethystine quartz. In some places the central bands consist of amethystine quartz, and the outer part of white quartz. Dolomite occurs as minor gangue mineral and a light yellow carbonate of the composition of ankerite is also fairly abundant. On the 250-foot level are numerous small stringers of light pink calcite. Most of these are less than an inch in width and as a rule cross the bedding of the shales at steep angles.

A study of some polished sections of the ore brought out some facts with regard to its paragenesis. A specimen composed largely of dark sphalerite was found to contain the iron sulphides, pyrite and marcasite, of which marcasite was the younger. The latest sulphide introduced was galena which occurs as veins traversing the other sulphides; its deposition was probably in the nature of a replacement. Though essentially belonging to one period of mineralization, there seems to have been a certain order of deposition among the vein minerals, but, undoubtedly, the periods of deposition of all the minerals overlapped. The first period was largely occupied by the deposition of quartz. Then followed iron and zinc sulphides of which marcasite was the latest. Later still came solutions which deposited lead, and, last of all, quartz and carbonate.

Origin of the Deposits. The deposits are believed to be genetically related to the deep-seated intrusive rocks of the area. Siliceous sulphide-bearing solutions from the magma in the later stages of its crystallization probably travelled along lines of fracture for considerable distances from their source and deposited their sulphide and silica content along these fracture planes and in brecciated zones. The shales were the most influential in causing precipitation from solution. Earth movement continued during this period of mineralization. The veins were repeatedly reopened and even after vein deposition ceased, further faulting took place.

Development. Sixteen veins have been exposed by surface workings. Only the main ones have been shown on the map of the region around the mine (Plate IV B). All of these show ore where they have been opened. The main vein, and the best developed, is the Federal or No. 1. It has a known length of approximately 600 feet and an average width of 8 feet. In places it is considerably wider than this and in addition is bordered locally by mineralized breccia. Several other veins intersect it.

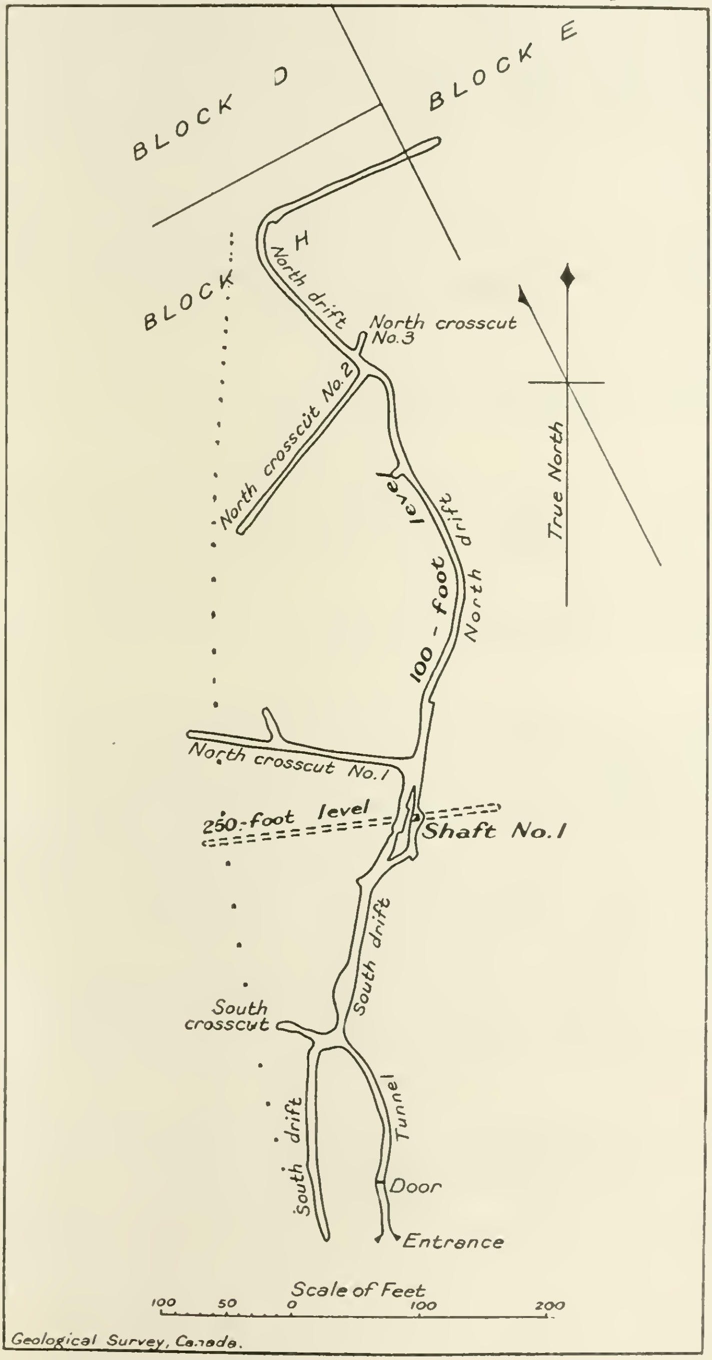


Figure 7. Plan of underground workings, Federal Zinc and Lead mine, Lemieux township, Gaspe county, Quebec.

With more development it may be found that other veins compare favourably in size and quality with the Federal. Two of these possibilities require mention. The first is the McKinlay, or No. 16, which forms a large, abrupt outcrop on Federal hill 900 feet southwest of No. 1 shaft. This is a large vein whose length has not as yet been determined by trenching, but which is exposed in the road to the east of the main outcrop. It has a width of 60 feet which includes, however, a horse of country rock. The vein contains high-grade ore and is bordered on the north by breccia. The other possibility is No. 14, or the Bois. It has been traced by trenches and sunk on for 64 feet. The vein has a maximum width of 18 feet and shows the usual mineralization, with the local addition, however, of more chalcopyrite than is present in the Federal vein.

Most of the exploration has been carried out from No. 1 shaft on the Federal vein. This was originally sunk 100 feet on an incline following the vein, but later, a vertical shaft was sunk from the surface to a depth of 257 feet. The amount of horizontal workings from this shaft is as follows (*See also* Figure 7):

	Feet
Drifting—	
North drift (100-ft. level)	657·3
Drift from No. 1 west crosscut north (100-ft. level)	34·2
South drift (No. 1 level)	360·8
Drift around Federal shaft (100-ft. level)	73·8
	1,126·1
Crosscutting—	
No. 1 west crosscut north (100-ft. level)	180·4
No. 2 " " north " "	164·0
No. 1 east " north " "	30·9
No. 1 west " south " "	48·0
Adit 100-foot level	126·8
Adit 250-foot level	104·0
West crosscut 250-foot level	165·0
East crosscut 250-foot level	61·0
	880·1

The Gilker or No. 2 shaft has been sunk to a depth of 18 feet, and the Bois or No. 3 shaft to a depth of 64 feet.

The rock at the portal of the 100-foot level consists of shales, in beds of from 2 to 4 inches thick striking north 75 degrees west and dipping 55 degrees southwest. The rock is finely jointed and traversed by small quartz stringers along the jointing and bedding planes. About 75 feet from the portal a breccia zone 12 feet wide contains a network of stringers with some masses of yellow zinc blende. From this point to within 20 feet of the south drift, the shales are poor. This last 20 feet, however, consists of breccia with some sphalerite.

The south drift follows a vein the foot-wall of which is sharply defined but whose eastern border fades out into brecciated shale. The vein as exposed here is from 5 to 8 feet wide and consists of quartz and carbonate with sphalerite and galena, and numerous small horses of shale with a part of the vein in the foot-wall. The foot-wall follows a post-mineralization fault plane marked by a zone of crushed shale which varies up to 6 inches in width. The short south crosscut exposes heavily-bedded dark shales. A little ore is exposed at one place in the face, but there is no definite vein. Two parallel light-coloured zones of soft material, ½ to 6 inches in width, which follow the bedding planes and which are evidently minor shear zones, occur in this crosscut.

The drift, north of its junction with the adit, cuts through vein and mineralized breccia material (Plate V). In places the vein carries a series of parallel bands of amethystine quartz showing a succession of reopenings and closings. A large horse of shale 10 feet long and 2½ feet high is present in the mineral zone. Immediately south of the shaft the vein is from 12 to 16 feet wide.

At the north crosscut the fault plane which borders the south drift is well marked; 1½ feet to the west of it another fault is seen parallel to it. At 65 feet along the

crosscut is still a third fault which runs at right angles to the crosscut. The north crosscut traverses shale in beds from 1 to 6 inches in thickness and contains a few stringers of vein material. A short drift from the north crosscut follows a vein 5 feet to 6 feet wide which is probably the underground extension of No. 3 vein, and carries high percentages of ore.

North of the shaft the main drift follows the Federal vein which here shows quartz and ore up to 12 feet in width bordered by a zone of mineralized breccia. At 180 feet north of north crosscut No. 1 the vein is cut off by a fault plane dipping at an angle of 50 degrees to the east. The fault plane is an open fissure and strikes north 45 degrees west.

North of this fault the north drift follows a vein known as the porphyry from the fact that it parallels a band of light-coloured rock, though throughout its exposed length there is a band of black shale 1 to 3 feet wide between the vein and the light grey rock. This rock, which is approximately 50 per cent carbonate, is apparently a porphyry intrusion, highly altered by carbonated solutions. In places it contains disseminated masses of zinc blende. The vein has a width of from 1½ to 6 feet, is bordered by breccia, and has been followed for 200 feet. It contains rich zinc and lead values. South of the turn in the drift, the vein disappears, but, 35 feet east of the bend, a vein 3 feet wide—a continuation of the Porphyry vein—crosses the drift. From here to the breast of the drift the walls show nothing but shale striking north 67 degrees east and dipping 27 degrees southeast.

North crosscut No. 2 is driven through shales and dense, dark-coloured crinoidal limestone for 55 feet and then passes into porphyritic syenite. This rock is fresh and massive, but shows local slickensided fractures and small quartz stringers. North crosscut No. 3 exposes only shales.

On the 250-foot level, a total length of 226 feet of crosscutting has been done. East of the shaft the rocks exposed consist of shales and limestones. These rocks are interbedded, but in places irregular masses of limestone are surrounded by shale—a condition brought about by the deformation of the beds. Near the east end of the crosscut some rich ore has been exposed. On the north side is a vein zone 4 to 5 feet wide containing zinc blende and galena in large masses and bordered by a broad breccia zone. Directly opposite, on the south side, is a rich zone 12 feet wide. A fault plane appears on the roof of the crosscut on the north face and cuts the south face about 2 feet above the floor of the crosscut. The fault is parallel to the bedding of the shales. Either two veins have been brought together at this point or there has been faulting across a vein bringing a wider part over a narrower part. The fault plane shows a marked gouge zone and slickensided striations.

West of the shaft the crosscut shows a number of features of interest. Ten feet from the shaft is a brecciated vein zone containing ore. Fifteen feet farther on is a fault plane dipping 20 degrees to the east which is open in places and forms a water course. Several other faults are exposed in this crosscut and a few small veins with accompanying breccia zones. Numerous veinlets of pale pink calcite here cut the shales.

Ore Values. The veins exposed throughout the workings show good values in zinc and lead ore, and even the brecciated zones are in places rich enough to be mined. The following is a list of assays from samples cut across the quartz veins at various points and across some of the brecciated zones. The samples were taken by Dr. Walter Harvey Weed and are given here through the courtesy of the Federal Zinc and Lead Company.

Samples

No.	Location	Thickness	Lead	Zinc
		Feet	%	%
1	Between tunnel and south drift	12		
2	Quartz-spar vein next to wall opposite south drift	8·4	2·8	8·2
3	Breccia, east of No. 2	9·5	0·0	1·0
4	Across vein north end south drift	6·3	3·1	11·1
5	South face, end south drift	6·5	14·1	5·8
6	Vein at 61 feet south of inclined shaft, foot-wall	6·0	6·6	4·4
7	Vein at 61 feet south of inclined shaft, hanging-wall	5·4	3·4	3·9
8	Point 20 feet north of No. 7, 41 feet from shaft, hanging-wall	6·0	0·9	3·6
9	Point 20 feet north of No. 7, 41 feet from shaft, hanging-wall	6·0	0·9	6·8
10	At first crosscut northwest of shaft	8·2	1·5	3·2
11	30 feet north of No. 10	6·0	2·5	15·3
12	22 feet north of No. 11	6·0	3·0	8·3
13	30 feet north of No. 12	4·8	2·2	8·4
14	16·2 feet south of Survey Hub No. 8, 20 feet north of 13	3·5	9·5	15·3
15	12 feet north of Survey Hub No. 8	6·0	9·2	8·3
16	46 feet north of Hub No. 8	6·0	1·2	5·7
17	Crosscut to east breccia at end of east crosscut	10·0	0·0	3·9
18	Breccia west of 17	10·0	0·0	trace
19	Across vein over porphyry in crosscut west for 10 feet from drift	7·5	0·0	3·3
20	Breccia corner of east crosscut north side next to drift and to No. 18	4·3	0·0	1·1
21	35 feet from east crosscut	4·0	0·2	2·7
22	12·6 feet beyond No. 21 opposite fault	10·0	2·3	8·2

"A composite sample representing equal parts of material from twelve cuts across the Federal vein from the extreme south end to the northernmost point exposed shows 3·8 per cent lead and 7·9 per cent zinc with 9·46 per cent lime and 43·85 per cent silica. This composite sample is considered as representative since it checked up closely with the calculated average of the individual assays and it may be accepted as an average for the entire vein so far as exposed underground".

The assays show that the lead content of the veins and brecciated zones varies from nothing up to 14 per cent and the zinc up to 15 per cent.

Conclusion Regarding Deposits. The development which has been carried out so far indicates that there is a large quantity of ore in sight. With regard to the persistence of the veins in depth, vein outcrops have been found throughout a vertical range of 560 feet, this being the difference in elevation between a vein exposed in a cut for a road in the valley bottom and that of the outcrops on the summit of Federal hill. It is probable that such strong veins as the Federal, the Porphyry, the McKinlay, and others extend to much deeper than this. It is commonly assumed that a vein is as deep as it is long; hence, a depth of 1,000 feet or even considerably more is quite to be expected. Should this prove to be the case the Federal would have an available tonnage that would make this one of the large zinc properties of America. The ore is of excellent quality, is in no way complex, and should be easy of concentration. The handicap at present to further development is lack of good means of communication.

OTHER PROSPECTS

The North America Mining Company holds the mining rights on claim $\overline{\text{L}}$ and several other claims of the area. On claim $\overline{\text{L}}$ a shaft has been sunk 30 feet and two open-cuts have been made. The veins opened up are similar in character and mineralization to those on the Federal Company's holdings, but so little work has been done that it is impossible to make any statement with regard to their possibilities.

The surrounding region deserves to be still further prospected. In addition to the zinc and lead deposits chalcopyrite has been found in several of the veins of the region which suggests the possibility of copper deposits being located. The contacts

of the Tabletop batholith with the Palæozoic sediments should also be searched for ore deposits. The serpentine belt likewise deserves to be thoroughly prospected. Chromite is known to be present in small quantities and it is possible that deposits of commercial importance may yet be found. Similar basic rocks in other parts of the world are also the source of platinum.

PETROLEUM

Locally the Gaspe sandstone of the map-area contains small amounts of bituminous material. Whether this series anywhere throughout the peninsula carries sufficient oil to be of commercial importance is a question of considerable economic interest. Present knowledge of the possibilities of oil in Gaspe may be very briefly stated. In order to have an oil field four things from a geological point of view are necessary.

(1) There must be oil in the region.
(2) There must be a favourable structure to give the oil an opportunity to accumulate.
(3) There must be strata of porous rock to serve as a reservoir to contain the oil.
(4) There must be an impervious capping rock over the reservoir to retain the oil.

It may be definitely stated that there is oil in Gaspe. Drilling for oil on York river was carried on for over 40 years and altogether 52 wells have been sunk, some of them to a depth of 3,700 feet. In 1901 and 1902 some 200 barrels of oil were obtained. Even the best of the wells, however, gave only a small daily yield which rapidly fell off to nothing on pumping. Nevertheless the occurrence of oil springs and the finding of oil in the wells even though only in small quantities shows that the peninsula does contain petroleum.

With regard to structure, the Palæozoic rocks of Gaspe are thrown into anticlines and synclines and at the eastern end of the peninsula the major structural features are known. Besides being folded, however, the rocks have also been faulted. The conclusions of Ells from his studies in this field was that faulting was so extensive that the oil had escaped along fissures instead of becoming concentrated in any reservoir. Very little, however, is known of the structure of the interior of the peninsula. The dips of the Gaspe sandstone are known in many places to be low and it is quite possible that there may be areas where there has been but little faulting and where the folding is sufficiently gentle to make favourable places for oil accumulation.

With regard to the third condition, that of a reservoir for the oil, the Gaspe sandstone itself is admirably suited for this purpose. If the series is continental there is very little chance of the series itself being an original source of oil except perhaps in some of the basal beds which are known to contain a marine fauna. Underlying the series, however, are the Gaspe limestones and older Palæozoic rocks of marine origin which may be a source of oil which might accumulate at favourably situated places in the Gaspe sandstone above.

The question of a capping rock is one to which a less satisfactory answer can be given. Shale occurs throughout the Gaspe series, but not in definite, widespread horizons such as are found in a marine series. Where it does occur, it is in local irregular beds which pinch out rapidly laterally. The question of a good cover would, therefore, seem to be the chief difficulty in the way of oil accumulation in the peninsula. A possible substitute for an impervious shale capping rock might possibly be found in the basic lava flows of the peninsula. As already mentioned, these are widespread in the area mapped. It might possibly be found that at some place of favourable structure they are of sufficent areal extent to serve as an efficient capping to an oil reservoir. A great deal of careful areal geological work would be necessary, however, before recommendations for drilling could be dependably made. The presence of igneous rocks interstratified with and cutting the sedimentaries is, on the other hand, not usually regarded as a condition favouring the existence and accumulation of petroleum.

SUMMARY

The zinc and lead deposits which have led to a new interest being taken in the economic possibilities of Gaspe peninsula are situated near the headwaters of the north branch of Berry Mountain brook, a tributary of Cascapedia river. They are reached by a wagon road from Cascapedia station on the Quebec Oriental railway which follows along Chaleur bay. This road follows Cascapedia river and Berry Mountain brook and from the railway to the Federal zinc and lead property is a distance of 46 miles. A great deal of work has been done on this road, but in order to put it in condition for efficient summer transportation much still remains to be done.

TOPOGRAPHY

The central part of Gaspe peninsula is a plateau with an approximate elevation of 1,800 feet. To the north lie the Shickshock mountains which reach elevations of over 4,000 feet. The upland topography is characterized by mature slopes; the interfluvial areas are as a rule flat. The valleys, however, which are deep and steep-sided, have evidently been produced by stream cutting following the uplift of a maturely-developed topography.

The region was apparently not overrun by the Pleistocene continental ice-sheets. Local glaciers were, however, present in the higher central part of the peninsula, and spread out in all directions, producing cirques and local changes in drainage, and transporting morainic material.

GENERAL GEOLOGY

The oldest rocks are shales and limestones of Lower Devonian age. These rocks are folded, faulted, and intruded by both dyke and deep-seated rocks. Overlying the shales and limestones is a sandstone formation, corresponding to the Gaspe sandstone of the coast sections. In this area it lies flat and contains plant remains. Flows of basic volcanic rocks are associated with the sandstone and cover the greater part of the map-area. Acid lava flows are in places associated with the basic flows. Many varieties of porphyry occur in the region. The plutonic rocks consist of syenite and granite, the syenite occurring as dykes and small stocks, the granite as a batholith which cuts across the structure of the folded Palæozoic rocks. The folding and intrusions took place, probably, in Middle Devonian times, since when the history of the region has been largely one of erosion.

ECONOMIC GEOLOGY

The ore deposits consist of sphalerite and galena in veins which cut the shales and limestone. In places the veins have sharply defined walls, in places they fade out into brecciated zones. The gangue is quartz and dolomite; some of the quartz is of the amethystine variety. The sphalerite is mostly light yellow and almost free from iron. The proportion of sphalerite to galena is about two to one. Pyrite, marcasite, and chalcopyrite are present, but in only very small amounts. The deposits are considered to be genetically related to the deep-seated acid intrusives of the region.

A large number of veins have been exposed by surface trenching. From No. 1 shaft, on the Federal or No. 1 vein, a considerable amount of development has been carried out. From the 100-foot level, 1,126 feet have been drifted and 776 feet have been crosscut. From the lowest level—257 feet—over 200 feet of crosscuts have been driven. The workings have opened up a large amount of ore, and the prospect for a large tonnage is very favourable.

POSSIBILITIES OF FINDING OIL OR NATURAL GAS AT EDMUNDSTON, NEW BRUNSWICK

By W. S. McCann

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INTRODUCTION

The following report contains the results of an investigation of reported occurrences of gas and oil at Edmundston, N.B. The work was greatly facilitated by the co-operation of Mr. Alec. Dunbar, who kindly furnished the writer with all available information.

GENERAL GEOLOGY

The rocks exposed near Edmundston are grey calcareous slates, with occasional thin beds of sandstone and quartzite of Silurian age. They have been extremely metamorphosed and are closely folded and faulted. A slaty cleavage, which is usually vertical, obscures in many places the original structural features of the rocks. In recent cuttings for the railway grade, bridge abutments, etc., however, the bedding planes are exposed well enough to permit of the determination of the attitude of the strata.

Evidence of close folding may be seen at the railway bridge at the mouth of Madawaska river, one mile east of Edmundston, and at the site of the new water tank on the northwestern corner of the town. At these points local synclines occur. Faults are of frequent occurrence, and add to the general complexity of the geological structure of the rocks.

ECONOMIC GEOLOGY

The reported indications of gas and oil are as follows:

	Explanation
Pump house. Fraser Co., Ltd., Madawaska river. Bubbles of gas rose to the surface of the water upon agitation of the bottom. The gas was accompanied by oil which spread over the surface of the water as an iridescent film.	Methane (marsh gas) accompanied by certain fatty acids or sulphite turpentine (cymene), which forms a film on the surface of the water.
Madawaska river behind the Madawaska Inn. Bubbles of gas continually rising to the surface of the water at various points, more or less in alignment nearly across the river. Small amount of oil accompanies the gas, which latter burns readily, if collected in a container.	Methane and oily substances noted above.
Drilled well at site of old Block House, east side of Madawaska river. Two wells were drilled at this point several years ago ostensibly for oil. It is alleged that the water from these wells was oily, and of disagreeable odour. Other wells in the neighbourhood are reported to have been disused because of peculiar taste and odour.	Stagnant water covered with film of iron oxide, from metal off the drill or from iron sulphides present in small quantities in the slates.
Madawaska river above sulphite-pulp mill. Upon agitation of bottom large bubbles of gas rose to the surface. This gas was *not* accompanied by oil.	Methane. Absence of material probably because of absence of waste products of pulp mill at this point.

INVESTIGATION OF REPORTED OCCURRENCES

Air-free samples of the gas were collected at various points, together with samples of the river water and water from the bored well at the site of the old Block House. These samples upon analysis by R. T. Elworthy of the Mines Branch yielded the following results:

Analysis of Gas Samples

——	I	II	III	IV
Carbon dioxide (CO_2)	2·8	1·8	1·1	None
Oxygen (O_2)	2·3	2·8	3·1	None
Methane (marsh gas) (CH_4)	91·4	71·5	67·4	80·0
Nitrogen (N_2)	3·5	23·0	28·4	12·8
Ethane (C_2H_6)	None	None	None	7·2
Density compared to air	0·615	0·685	0·698	

I. Sample collected at boiler house, Fraser Co., Ltd.
II. Sample collected 200 yards from west bank Madawaska river in rear of Madawaska Inn.
III. Sample collected in midstream Madawaska river in rear of Inn.
IV. Sample of natural gas, Moncton, N.B., included for comparison.

The analyses of the gas show that it is largely methane or marsh gas (CH_4). The gas shows no trace of higher hydrocarbons such as ethane and propane which are usually found in natural gas. The small amounts of oxygen compared with the amounts of nitrogen in II and III are accounted for by the increased solubility of oxygen in cold water. (Oxygen is about 2·5 times more soluble than nitrogen.)

The gas, at the time of collecting, smelled strongly of hydrogen sulphide (H_2S), but the analyses do not indicate its presence, perhaps because some water was left in the jars in which the gas samples were collected, and the H_2S was dissolved by it. Some CO_2, also, was probably dissolved in the same way.

Analyses of Water Samples

A sample of water from Madawaska river below the sulphite-pulp mill was found to contain 75 parts of mineral matter per million parts of water. This mineral matter was composed of calcium sulphate and sodium chloride, and the water was slightly alkaline in reaction.

Water collected at the bored well at the site of the old Block House contained 673 parts per million mineral matter composed of calcium and manganese bicarbonates and sulphates, sodium chloride, and traces of iron hydroxide, the latter forming a film on the surface of the water.

No trace of oil was detected in either sample.

PROBABLE EXPLANATION OF THE PRESENCE OF OILY SUBSTANCE

Accompanying the gas bubbles in the river below the sulphite-pulp mill there are small amounts of an oily liquid which forms an iridescent film on the surface of the water. It occurs in such small amount that it was impossible to collect enough for testing or analysis. In the river above the sulphite-pulp mill, the marsh gas which rose to the surface of the water upon agitation of the river bottom was not accompanied by an oily substance. This fact points toward the waste products of the pulp mill as a possible cause of the continuous bubbling of gas and the presence of the oily liquid.

Madawaska river below the place where the gas occurs is dammed, so that there is little current. In former years there was a sawmill on the east bank of the river, but it is possible that most of the sawdust was swept out into St. John river. Some

of it, however, may have lodged in places where eddies occurred. It is known that the decomposition of sawdust at the bottom of rivers, even of swift current, produces marsh gas in sufficient volume sometimes to break the ice covering it in winter. It is not certain, though, that the gas observed has resulted from sawdust, and another explanation must be sought.

Now, mangled bark, resins, and gums in large quantities are being discharged into the river along with other waste products of the pulp mill, including so-called sulphite turpentine, a compound largely composed of cymene, which is an oily substance. Also, in the decomposition of the cellulose of the organic materials at the bottom of the river certain fatty acids (butyric acid, valeric acid, etc.) of molecular weight less than that of cellulose, are produced. Such substances would rise to the surface and spread over the water as an oily film. In this way the oily substance may be accounted for.

ABSENCE OF OIL OR GAS IN NORTHERN MAINE

The reported discoveries of oil or gas in Maine have been found to be without foundation. Mr. Freeman F. Burr[1] states:

"The search for oil in this state (Maine) is probably fully as hopeless as that for coal. . . . Oily material in small quantities may occasionally appear in connexion with surface deposits, since such material is a product of animal and plant bodies: but the chances are almost overwhelming against the finding of oil in the underlying rocks, chiefly because these show abundance of evidence of having been folded and fractured to such an extent that any volatile materials would inevitably have been expelled into the atmosphere long ago. It seems best to discourage any expectation of oil anywhere in Maine."

The reported discovery of oil near Dover on the Piscataquis river is not endorsed by the Maine Water Power Commission.[2] Samples of the supposed oil, which were sent to the University of Maine for analysis, were reported to be refined oil.

CONCLUSIONS

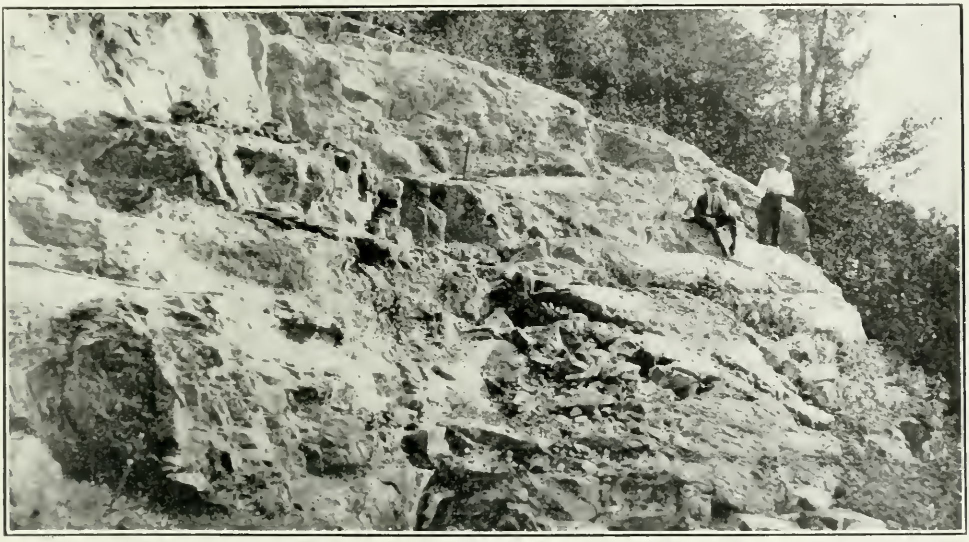
The rocks of the district are extremely metamorphosed, highly folded and faulted, and are not, therefore, favourable for the retention of oil or gas.

The gas which occurs is marsh gas (methane) and has resulted from the decomposition of organic materials at the bottom of the river.

The oily substance which spreads over the surface of the water in small amounts is probably cymene (sulphite turpentine) or certain of the fatty acids resulting from the decomposition of organic materials on the river bottom.

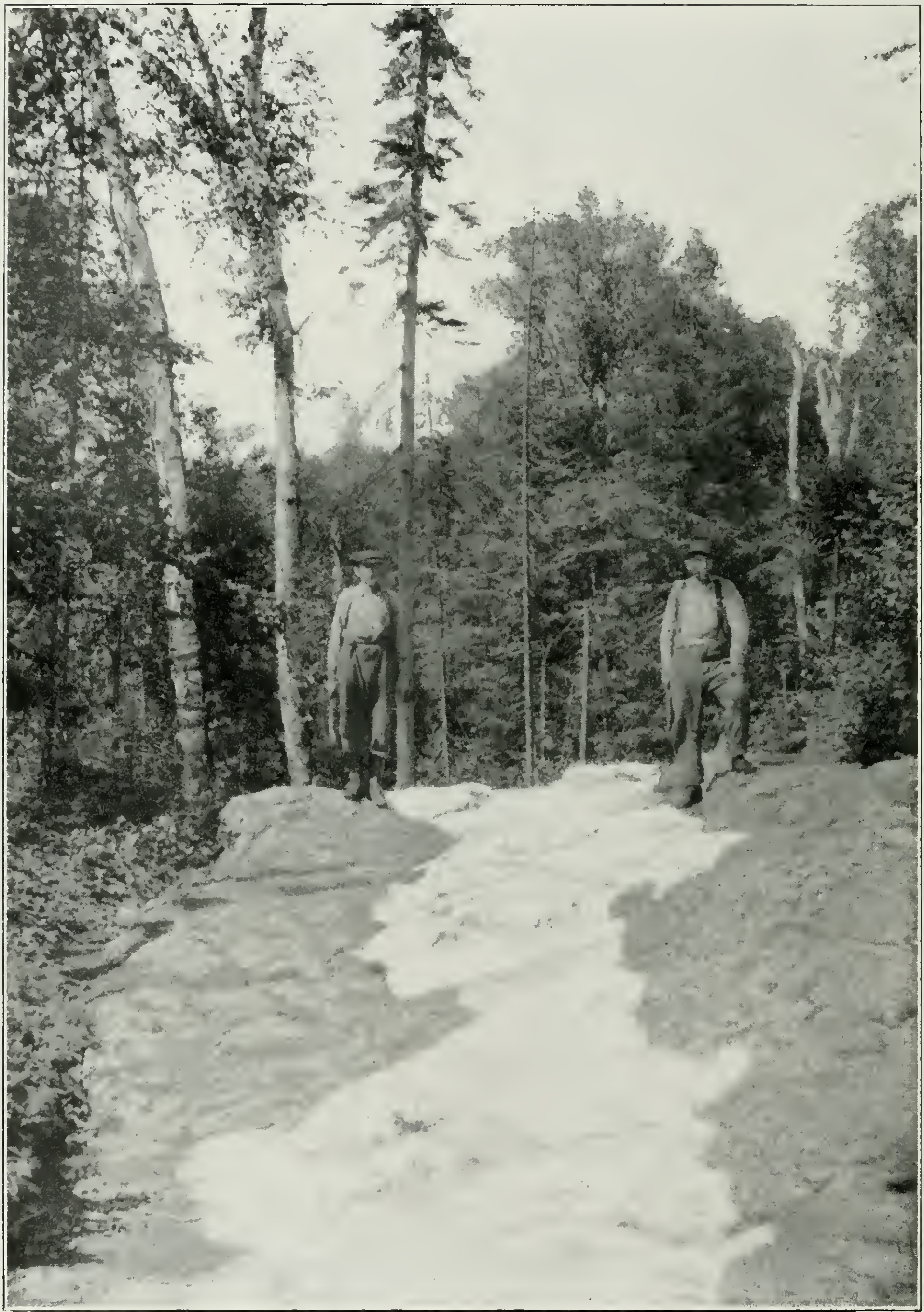
[1] Geologist, Main Water Power Comm., 1st Ann. Rept. M. W. P. Comm., 1920, p. 116.
[2] Personal communication.

PLATE I



Uraninite-bearing dyke of segregated type—McQuire-Robertson claims. Lots 9 and 10, concession IX, Conger township, Parry Sound district. (Page 61.)

PLATE II



Segregated veinlike dyke—white quartz in middle, feldspar at sides. Ryan, Mann, Sheehan claims, lot 3, concession VI, Butt township, Ont. (Page 56.)

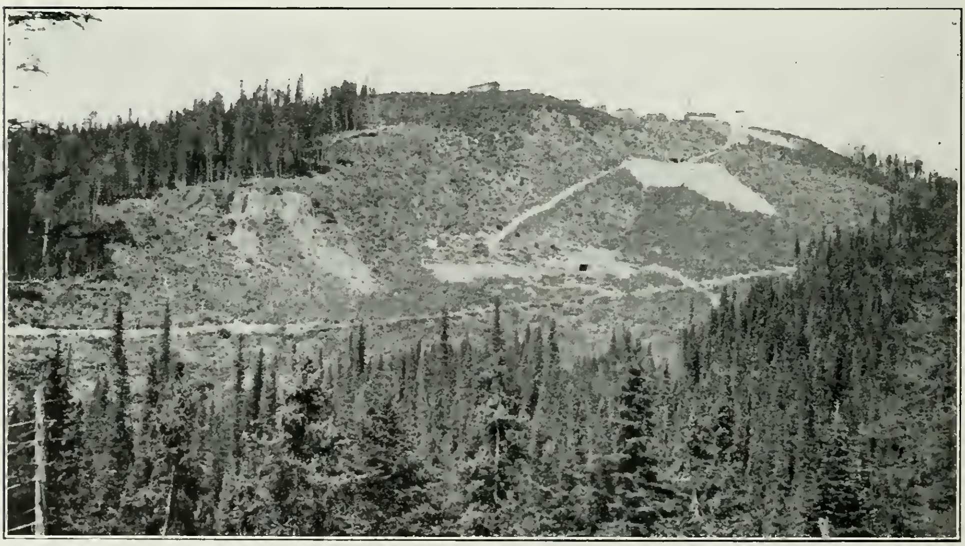
PLATE III

A. View down Berry Mountain brook from the Federal mine, showing the plateau surface. (Page 76.)

B. Ste. Anne river below Ste. Anne lake, showing the youthful character of the valley. (Page 76.)

PLATE IV

A. View on the top of mount Albert, showing the unglaciated surface. (Page 78.)



B. Federal Zinc and Lead mine from across Berry Mountain brook. (Page 90.)

PLATE V

Brecciated shales and limestones, mineralized with sphalerite and quartz. Approximately natural size. (Page 92.)

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[1]NOTE. All localities unless otherwise designated are in Ontario.

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